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ABSTRACT

This guide contains lesson plans and outlines of activities which introduce students to concepts and issues relating to solar energy. Lessons frequently presented in the context of solar energy as it relates to contemporary energy problems. Each unit presents an introduction; objectives; necessary skills and knowledge; materials; method; questions; suggestions for further work; and a teacher information sheet. The teacher information sheet provides target grade level subject areas involved for the lesson and background material; hints on gathering materials for the lesson; suggested time allotment; suggested approach; typical results; precautions; modifications; evaluation; and references. (RE)

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DOE/CS-0061

Activities

General Solar Topics

ED173163

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SOLAR ENERGY PROJECT

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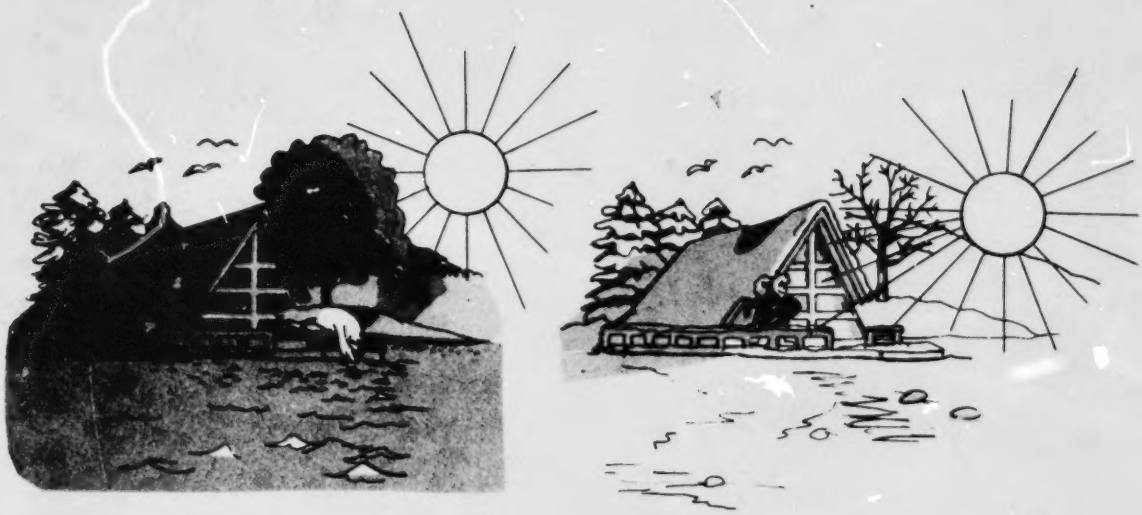
A PASSIVE SOLAR HOUSE



INTRODUCTION

Have you ever sat in front of a window and felt the sun's energy strike you? Windows in a house are very good solar collectors. They allow the sun's energy in and trap much of it so that little escapes. All you need is a window facing the sun and a method such as drapes for limiting its cooling surface when there is no sun.

This activity will have you consider ways to orient a house and landscape the lot to get maximum benefit from the sun's energy without using complex solar collecting systems. Be imaginative and you might be able to make suggestions to others which will help them more effectively utilize the sun's energy.

OBJECTIVES

At the completion of this activity, you should be able to:

- o understand the basic features required in a simple passive solar heating design.
- o apply your knowledge of vegetation to landscaping arrangements that conserve energy in buildings.
- o apply your knowledge of the angle of the sun during different seasons to the problem of building design.

SKILLS AND KNOWLEDGE YOU NEED

- Basic cutting, taping and diagramming skills.
- The sun's rays strike the earth at a more shallow angle in winter than summer.
- Winter winds come from a particular direction in your locality.

MATERIALS

- Scissors.
- Tape.
- Straight edge.
- Worksheets A, B, and C.
- Light Source (filmstrip projector, lamp, etc.).

METHOD

1. Cut and fold the model dwelling and assemble without taping. (Worksheet A)
2. Place the folded model dwelling on the plot plan (Worksheet B) and decide on the setting of the dwelling. Make decisions about the room, windows and door placements. Unfold the dwelling and draw in the windows and doors.
3. Refold and tape the dwelling. Then tape the roof in place. Place the taped model dwelling on the plot plan. Cut out the model trees and shrubs and fold the bases. Use as many tree models as you desire to landscape the plots by taping the models in place. Remember, most deciduous trees lose their leaves in fall.

4. Set the light source at the approximate angles for the winter and summer sky. Check the effectiveness for winter heating and summer shading of your landscaped plot. Be sure to replace summer deciduous models with winter models and visa versa.

LOOKING BACK

You have designed and constructed a model home which will take advantage of the sun's energy when it is most needed. Your design should help you answer the following questions.

QUESTIONS

1. How does your dwelling compare to those of other students in placement of windows, size of doors and roof arrangements?

2. What are common procedures in landscaping passive solar homes?

3. In which direction should the largest roof overhang face to take advantage of winter sun while avoiding summer sun?

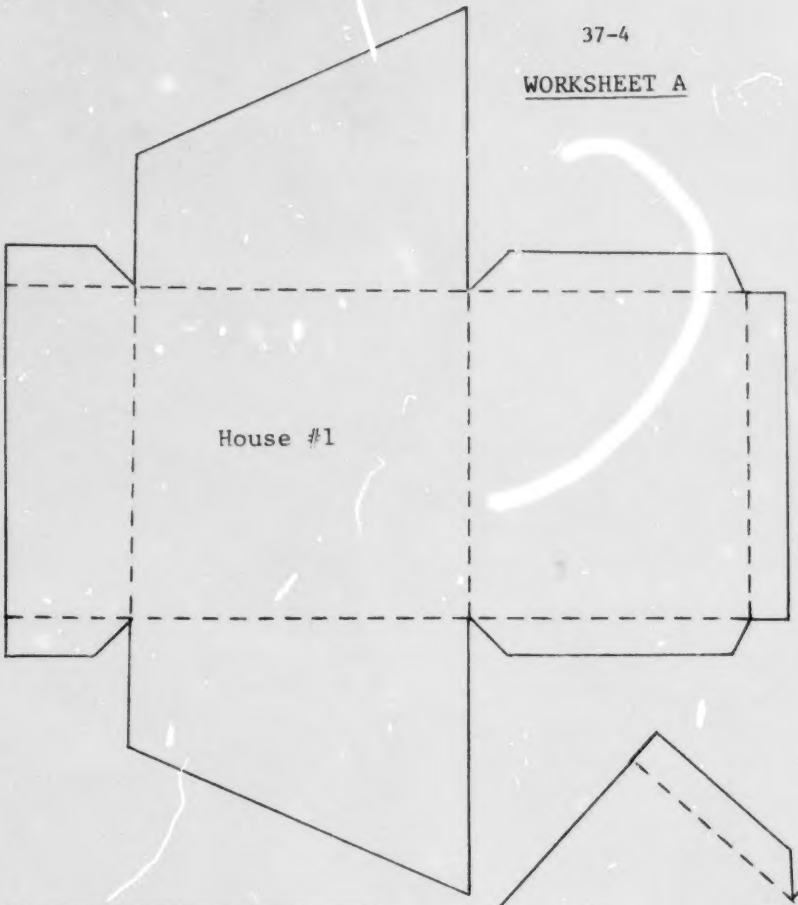
GOING FURTHER

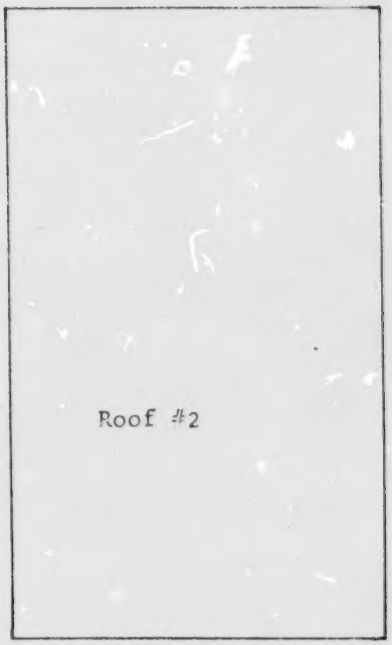
- Obtain other copies of Worksheets A, B, and C. Redesign and landscape the same house for an active solar energy heating system. Place flat plate solar collectors on the roof. Determine the most efficient roof pitch for such a system and re-draw the sidewalls to obtain this pitch.

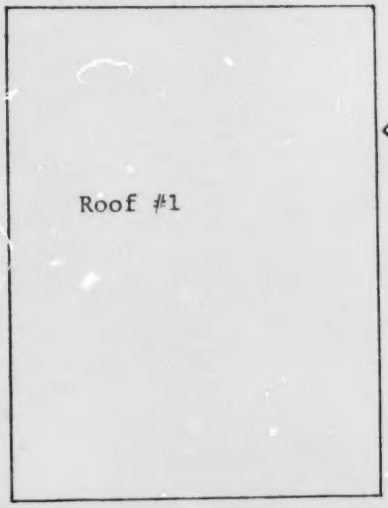
- Obtain other copies of Worksheets A, B, and C. Redesign the same house to include a cooling system, such as an evaporative cooling system. What factors will have to be considered for such a system?

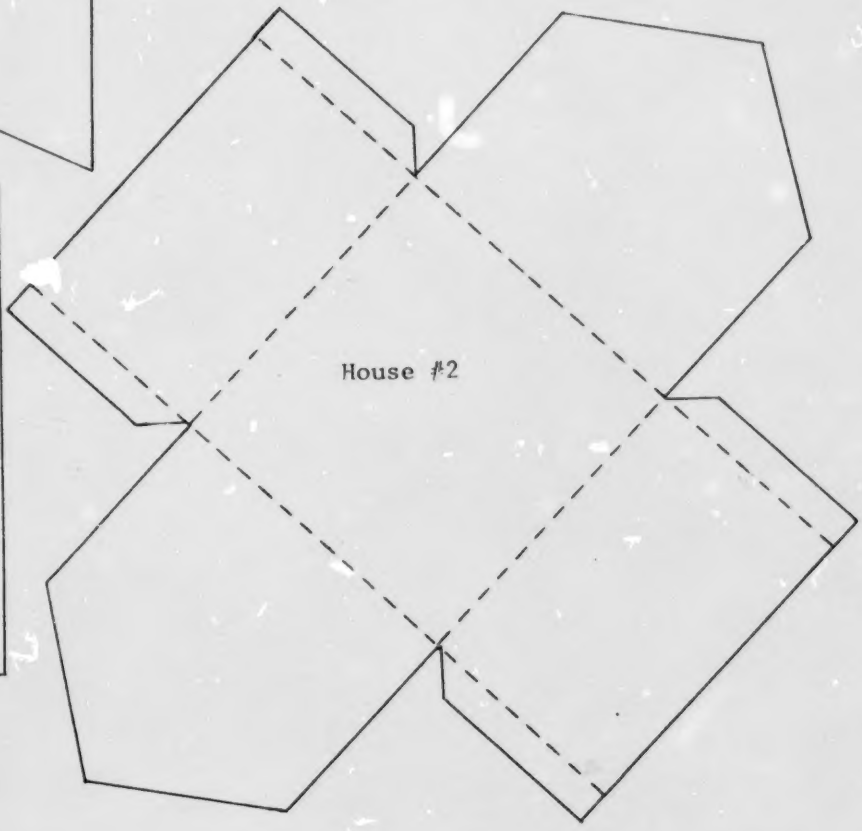
- Construct a model home from other materials such as wood or plaster of paris incorporating various passive solar design features.

WORKSHEET A



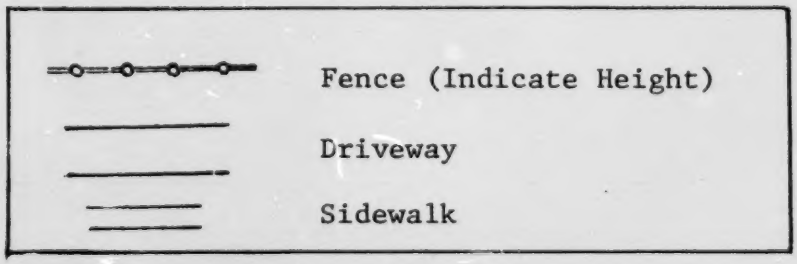






WORKSHEET B

KEY



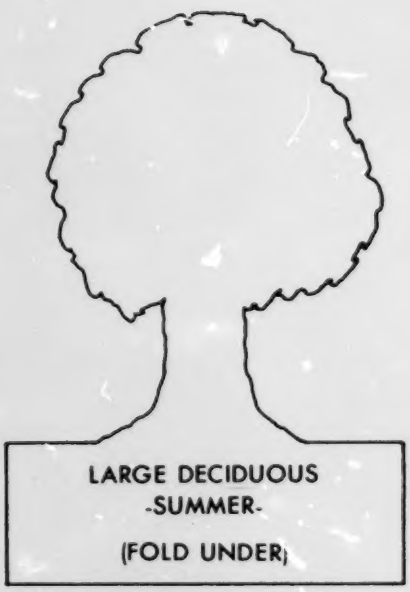
WORKSHEET C

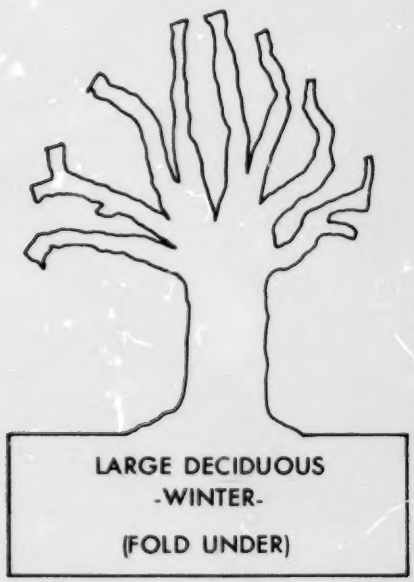
SHRUB
(FOLD UNDER)

SMALL DECIDUOUS
-SUMMER-
(FOLD UNDER)

SMALL DECIDUOUS
-WINTER-
(FOLD UNDER)

EVERGREEN
(FOLD UNDER)


LARGE DECIDUOUS
-SUMMER-
(FOLD UNDER)


LARGE DECIDUOUS
-WINTER-
(FOLD UNDER)

Teacher Information Sheet

A PASSIVE SOLAR ENERGY HOUSE

Suggested Grade Level and Discipline

7-12 Science
Home Economics
Consumer Education
Industrial Arts
Agriculture Education

Background Information

Passive use of solar energy involves using the sun's energy to heat a structure or substance without the need for any other energy source to accomplish energy transfer. The antithesis of this is the active use of solar energy which usually involves pumps and/or fans powered by electricity to accomplish the energy transfer.

There are various designs for passive solar systems, many of which were created by individuals for their own unique situation. Passive solar energy use involves many simple ideas that a homeowner can incorporate into a new home or an existing home.

The underlying principles involved in using passive solar energy for heating combine various structural patterns with landscaping to have the maximum use of the sun during the cold weather and minimum use of the sun during warm weather. To accomplish these ends, an overall site plan for a building lot must be devised based on some elementary knowledge of the sun's position at various times during the year. Most of the information about the motions and positions of the sun is available for a given locality from weather bureau publications. However, specific features on or near a building lot must be studied to account for their effect on the sun's availability at various times of a day or year. Hills, large trees, and other structures are some of the factors that can directly affect the availability of sunlight for a given locale. It is best, if a new building is to be built, to collect information about the sun's availability before deciding on the orientation of the building.

For a new building, certain structural design features will make passive solar heating attainable. Windows should be maximized on the south and west sides of the building and minimized on other sides. The windows should be at least double glazed on the south and west sides and tripled glazed on the other sides. An overhang should be built on the south and west windows which cuts out the sun during the summer and early fall and allows the sun to penetrate during late fall, winter and early spring. The windows on the sun side of the house should be covered at night with insulating drapes or by other means to keep the warm house air from contacting the cooler windows. The house should be properly insulated and weatherstripped to avoid infiltration and conduction heat losses as much as possible.

The landscaping of a building can contribute to best use of the sun's energy. Deciduous trees should be located on the south and west side of the building. Their leaves will shade the house in the summer and when their leaves fall will allow the sun to strike the building during fall and winter.

Coniferous trees should be located on the wind side of the building. They provide very good wind breaks for the prevailing winds in an area. Wind usually increases infiltration heat losses from a building. Reducing the wind should cut these losses.

This activity encourages the students to be creative in designing a passive solar home. Many other passive solar designs are available. Students might investigate them by reading the literature and incorporating a more complex system into their designs.

Hints on Gathering Material

- Scissors, tape, pencils and straight edges should be available for all students. (Toothpicks, see Suggested Approach)
- Worksheets A, B and C can be reproduced by various copying machines on heavyweight paper or traced onto a ditto master.

Suggested Time Allotment

- Two class periods.

Suggested Approach

- Have the students work individually and compare results after completing their designs.
- Leaving some of the work on display will encourage further discussion and investigation.
- An alternative would be to assign the activity for homework and follow up with a full period of display and discussion directed by the teacher.
- Tape toothpicks to backs of trees for added strength.

Typical Results

- The objectives are simple and will be achieved by virtually all students.
- Construction of the dwelling and various landscapes will vary a great deal in artistic quality and should not receive a great deal of emphasis as these aspects are not directly related to the objectives.

Precautions

- *Scissors will seldom fail to return to the equipment storage if they are attached with a cord to 6cm wooden blocks.*

Modifications

- Modify the activity for students with greater sophistication by encouraging precise measurement of sun angle, roof pitch, overhang length, etc.

- Encourage the artistic student to design interior room spaces based on the best energy utilization.

Evaluation

- Evaluate each design by inspection and discussion with the students.

- Points to look for when evaluating students' work:

  a. Most windows should face south and have a roof overhang for summer use.

  b. Deciduous trees should be planted or oriented to the south and west sides of the house.

  c. Evergreens should protect the house from the prevailing winds in a given locality.

References

- *Energy Book #1,* John Prenis, editor, (Running Press, Philadelphia, Penn.), 1975, pp. 112.

- *Passive Solar: A Controlled Experiment in Home Heating,* Arthur Fisher, (Popular Science), April, 1978, pp. 76-79.

- *Solar Energy, The Ultimate Powerhouse,* John L. Wilhelm (National Geographic) March, 1976, pp. 392-393.

CAREERS IN SOLAR ENERGY

INTRODUCTION

Solar energy may well be a major energy source in the 21st century. Even now much experimental research in solar energy is being conducted, and solar construction and pilot projects are springing up worldwide. All are testing the possibility of solar energy as a future replacement for today's fossil fuel industries. New solar technology could revolutionize the energy field.

But what does this mean for future careers in the field of energy? What kinds of careers and jobs are available now, and what ki might be in demand twenty years from now?

In this activity you will examine solar energy os and careers and the effect they could have on your own career choices.

OBJECTIVES

At the completion of this activity you should be able to:

- o list possible jobs and careers in the solar energy field.
- o report the results of a literature search for information about solar energy jobs and careers.
- o determine the skills and education required for a particular solar energy job.
- o define and discuss technical terms relating to solar energy concepts.
- o explain the purpose of career education.

SKILLS AND KNOWLEDGE YOU NEED

- How to do research in the library or media center using periodicals and reference materials.
- How to analyze words and terms for pronunciation and meaning.
- How to relate job skills to education skills.
- How to communicate with business personnel.

MATERIALS

- A notebook in which to keep career information.
- The Reader's Guide to Periodical Literature.
- The employment sections of large circulation newspapers, such as The New York Times or The Philadelphia Enquirer.
- Periodicals (magazines).
- A word glossary.
- Manufacturers' lists.
- Career guidance library.

METHOD

1. Discuss the concept of career education with your teacher and other members of your class. Then define the term.

2. Using The Reader's Guide to Periodical Literature, and recent magazines and news articles, conduct a literature search for articles and information on solar energy jobs and careers. Also use your career guidance library to obtain additional career information on this topic. Keep a "jobs and careers" notebook containing the information you have obtained, along with any articles or information which you were able to find.

3. Search the employment sections of various newspapers for advertisements relating to solar energy jobs and careers. If possible, cut these out and place them in your notebook.

4. Using the results of your literature search and the employment ads you found, develop a list in your notebook of jobs and careers in the solar energy field. For each, determine what the job is, and what educational levels and skills are required. Both the ad itself and your career guidance library will be helpful for this.

5. Listed below are some of the processes used in the solar energy industry. Working in a small group with 2 or 3 other class members, define the processes in your notebook. A word glossary may be helpful.

collection	circulation	design/construction
conversion	storage	development
transfer	distribution	experimentation

6. Listed below are some of the materials and equipment used in the solar energy field. Working with your group again, explain in your notebook what each refers to.

collector	valves	furnace
system	metal ducts	heat exchanger
storage tank	piping	insulation
pump	gauges	

7. Working with a partner, arrange to go out and interview someone working in the solar energy industry, such as a businessman or an installer of solar systems. Also interview representatives from state, federal, and local agencies who would be knowledgeable about jobs and careers in solar energy. Arrange for some class

members to interview the school guidance counselor for information on career possibilities in solar energy.

8. Working in a small group, develop a list of jobs and careers which will be affected by solar energy.

9. Working in a small group, develop a list of solar energy jobs and careers which may be in demand ten to twenty years from now. (This will require some creative thinking.)

LOOKING BACK

By now, you should have a good idea of the job and career possibilities in the field of solar energy. You have found that job and career opportunities are most easily discovered through a search of magazines and newspapers, as well as through direct contact with businessmen, industry representatives, and your guidance counselor. Have you found a job or career which might interest you?

QUESTIONS

1. How many different jobs and careers did you list in your notebook?

2. Make a list of solar energy jobs which require each of the following educational levels:

   a. No high school diploma required.
   b. High school diploma.
   c. 2 years of college or vocational training.
   d. 4 years of college.
   e. Advanced degree (Master's or Ph.D.)

3. Where are the best places to look for solar energy job and career opportunities?

4. Are there any new, unusual, or interesting job opportunties in solar energy? If so, what are they?

GOING FURTHER

- Make a list of satellite (indirect) jobs which will be affected by the solar energy industry.

- Keep an updated list over a period of time of new careers and jobs in solar energy.

CAREERS IN SOLAR ENERGY

Suggested Grade Level and Discipline

7-12 Science

Background Information

Career education is striving to provide an active relationship between the academic world and the world in which people earn a living. Most high school students do not have adequate knowledge of the career opportunties open to them, especially when there are tens of thousands of job titles in the United States, and especially when the number of these job titles increases almost too rapidly to keep track of them. Consideration of the job opportunities in a new and rapidly expanding field, such as solar technology, should help to bridge the gap.

The United States Office of Education has developed the cluster concept, which groups job titles in the following categories:

- Construction
- Manufacturing
- Agribusiness and Natural Resources
- Marine Science
- Environment
- Business and Office
- Consumer and Homemaking
- Marketing and Distribution
- Communications and Media
- Hospitality and Recreation
- Personal Service
- Public Service
- Health Opportunities
- Fine Arts and Humanities

Hints on Gathering Materials

- Information regarding solar energy careers can be obtained from the use of the references listed at the end of this Teacher Information Sheet. Additional information may also be obtained by contacting solar organizations and manufacturers.
- Announce ahead of time that a notebook will be required for this activity.
- It would be advisable to let your guidance counselors know ahead of time that this activity is planned so that they can be prepared.
- Your guidance department may subscribe to the computerized Guidance Information System (GIS). If so, this will make occupation information easily available through the nearest computer terminal.

Suggested Time Allotment

- This will vary depending on the depth of coverage you desire for this topic, and upon how many of the activities you assign to your class. Assignment of most of the activities would require 1 to 2 weeks for completion.

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Suggested Approach

- A thorough introduction to the basic concepts and principles of solar energy technology is needed before this activity will be successful. It is suggested that this activity be used near the end of a unit or set of activities on solar energy, so that students already possess basic knowledge of solar energy concepts.

- Students should be given a basic orientation to the concept of career education before this activity is attempted.

- Activities which require student creativity and independent thought should be encouraged to help maintain interest.

- Having students work together in small groups will also help to maintain interest and enthusiasm as well as to increase their total output. A brief introduction to the purposes of "brainstorming" may help activities 9 and 10 to be more successful.

Typical Results

- Some of the jobs and careers in solar energy which students will "discover" are listed below:

Insulation Installer
Auxiliary System Installer
Sheet Metal Worker
Fabrication Worker
Prefabrication Worker
Architect
Lawyer
Salesperson
Real Estate Broker
Appraisor
Assessor
Zoning Agent
Consumer Protection Agent
Home Construction Laborer
Standards Developer
Scientist
Insurance Agent
Investor
System Installer
Dealers
Builders
Maintenance Person
Repair Person
Bill Collector
Inspector
Carpenter
Mason
Electrician
Plumber
Air Conditioning Person
Heating Person
Cooling Person
Refrigeration Person
Glazier
Factory Worker
Crane Operator
Roofer
Pipe Fitter
Contractor
Legislator
Consultant
Engineer
Designer
Developer
Banker
Estimator
Researcher
Furnace Person
Trainer - Educator
Licenser

Precautions

- *Be sure to allow enough time for students to complete some of the longer-range activities such as the literature search.*

Modifications

- Depending on the desired depth of coverage, different numbers of activities may be assigned from the METHOD section, varying from only a few activities to most of the activities assigned.

- You may wish to ask a guidance counselor to address your class as a whole, rather than having individual students seek them out. The same might apply to business people and representatives from the solar energy industry.

Evaluation

- Answers to questions can be collected and evaluated for completeness for the extent to which the student researched the activity. Notebooks can be evaluated on the basis of extent of research. Lists of job and careers can be evaluated for understanding of career opportunties. Student involvement in the small groups can be evaluated for extent of participation. Interview results can be evaluated for depth of questioning and for understanding of solar concepts and job opportunities.

References

- *Careers in Energy Industries.* (Department of Energy, Washington, D.C.) (Pamphlet - FEA/A - 75/228)

- *Energy Sources and Careers,* (Billerica, Massachusetts: Megatech Corp.) (Booklet/transparencies) 1978

- *School Subjects and Jobs.* (Chicago: Science Research Associates, Inc.) 1971

- *Solar Energy: Potential Powerhouse for Jobs,* Work Life, August 1976 (Reprinted in Social Issues Resources Series, *Energy,* Vol. 2 - #33.)

- *The Dawn of an Industry,* Nation's Business, The Chamber of Commerce of the U.S., September 1974. (Reprinted in Social Issues Resources Series, *Energy,* Vol. 1, Article #79)

EFFECTS OF INSULATION ON HOME HEATING COSTS

INTRODUCTION

Your home, like any heated substance, loses heat to its surroundings. On a very cold day your house loses heat more rapidly than on a warmer day. What effect does insulation have on the amount of heat lost by your house?

In this activity you will be given the floor plan of a typical one-floor residential home. You will calculate the amount of heat lost by this house in a year for varying amounts of insulation. From this you will be able to compare the costs of heating this house for each amount of insulation.

OBJECTIVES

At the completion of this activity, you should be able to:

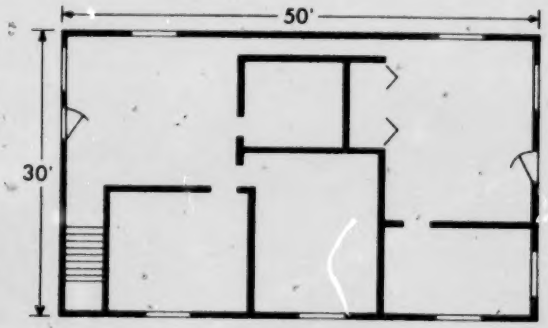
- o determine the total annual heat loss of a home.
- o calculate the amount of fuel used and determine the cost to heat the house per year.
- o compare the cost of heating a home when different thicknesses of insulation are used.

SKILLS AND KNOWLEDGE YOU NEED

- How to collect and organize data.
- How graph data.
- How to read tables.

MATERIALS

- A calculator is most helpful.
- Graph paper.
- Heating degree days data for your area.



METHOD

You are to consider the house illustrated above.

The house is a one-floor ranch resting on an unheated concrete floor with a completely exposed perimeter. The two doors are each 3' x 7'. The eight double-paned windows are each 2' x 5'. The walls are 8 feet high. In order to calculate the hourly loss of heat per degree Fahrenheit and eventually the annual cost of heat for this house, use the following steps and record your results in the appropriate tables and data sheets.

1. Calculate the area of windows, doors, and walls. Use the following formulas and place your answers in the appropriate column of Table 1: Calculation of Area.

   a. Windows = Number of windows x length x width.
   b. Doors = Number of doors x length x width.
   c. Walls = Total wall area - door area - window area.
   d. Ceiling = Length x width.

Table 1

Calculation of Area

	AREA (FT^2)
WINDOWS	_____
DOORS	_____
WALLS	_____
CEILING	_____

2. Computation of Total R values.

   The resistance of a material to heat transmission is known as its thermal resistance, or R value. R values for various materials are given below in Table 2.

Table 2

R Values for Various Thicknesses of Blanket-Type Fiberglass Insulation and Other Building Materials

MATERIALS	R VALUE
Ceiling Material	1.7
3" Insulation	11.1
6" Insulation	22.2
12" Insulation	44.4
18" Insulation	66.6
Double Paned Windows	2.0
Exterior Door	2.0
Wall Materials	2.5

To find the Total R for a given building structure, the R values of the individual materials composing that structure must be given without insulation. Table 2 indicated the R value for ceiling materials to be 1.7 and for wall material to be 2.5. Therefore, a ceiling with 3 inches of insulation would have a Total R value of 1.7 + 11.1 (R for 3" insulation) or 12.8. A wall with the same insulation would have a Total R value of 2.5 + 11.1 or 13.6.

Using the R values in Table 2, calculate the Total R value for each structure in Table 3.

Table 3

Total R and U Values

Structure	Total R Value				1/R = U Value
CEILING MATERIAL + NO INSULATION	1.7	+ 0	=		
CEILING MATERIAL + 3" INSULATION	1.7	+ 11.1	=	12.8	
CEILING MATERIAL + 6" INSULATION		+	=		
CEILING MATERIAL + 12" INSULATION		+	=		
CEILING MATERIAL + 18" INSULATION		+	=		
WALL MATERIAL + NO INSULATION	2.5	+	=		
WALL MATERIAL + 3" INSULATION	2.5	+ 11.1	=	13.6	
WALL MATERIAL + 6" INSULATION		+	=		
DOUBLE PANED WINDOWS			=	2.0	.5
EXTERIOR DOOR			=	2.0	.5

3. Computation of U Values.

The reciprocal of R is the U value. This is the amount of heat transferred in one hour through one square foot of wall or ceiling for each degree Fahrenheit of temperature difference between the air on the warm side and the air on the cold side of the building.

U is expressed in BTU's/(hr.) $(ft.^2)$ (^oF).

Using the formula U = 1/R, calculate the U value for each structure in Table 3. (U values may be rounded to the nearest tenth.)

4. Total Heat Loss per Hour x ^{o}F.

You can now calculate the total heat loss per hour ^{o}F of this house by using the formula:

Heat loss (q) = U x area

On Data Sheet 1, calculate the total heat loss in BTU's/hr. ^{o}F for the windows, doors, walls, and ceiling if the house had no insulation in either the walls or ceiling. Enter this calculation in the appropriate column of Data Sheet 2.

Now calculate the heat loss per hour ^{o}F for the other combinations of insulation given in Data Sheet 2. Use the remaining spaces in Data Sheet 1 for your calculations. Remember to enter this calculation in Data Sheet 2.

5. Floor

Due to the numerous computations necessary to compute the heat loss of an unheated concrete slab floor, it will be assumed to be 43 BTU/hr. ^{o}F.

6. Infiltration

A house will lose heat by infiltration, the process of heat losses by cold air coming in and warm air going out. The rate of infiltration for this house has been determined to be approximately 92 BTU/hr. ^{o}F. If you lived in a windy area, (top of mountain, etc.), the infiltration rate would be greater.

7. Completion of Data Sheet 2.

To show corrected heat loss, it is a good practice to add 10% to the total heat loss (BTU/hr. ^{o}F) to account for error. (For example, a total heat loss of 384 BTU/hr.^{o}F + a 10% error of 38.4 = Corrected heat loss of 422.4 BTU/hr.^{o} F.) Calculate the corrected heat loss for each category in Data Sheet 2 and enter the results in the appropriate column.

8. Heat Loss per Day ^{o}F.

Convert the total corrected heat loss per hour ^{o}F to heat loss per day ^{o}F by multiplying by 24. (For example, total heat loss of 422.4 BTU/hr. ^{o}F x 24 hours = 10,138 BTU/day ^{o}F.) Enter the results in the appropriate column on Data Sheet 2.

SAMPLE

DATA SHEET #1

AMOUNT OF INSULATION

CEILING _____ WALLS _____

COMPUTATION OF HEAT LOSS IN BTU/HR°F

(HEAT LOSS = AREA X U)

	AREA (FT^2) (TABLE #1)	X	U VALUE (1/R) (TABLE #3)	HEAT LOSS
WINDOWS				
DOORS				
WALLS				
CEILING				
FLOOR	X		X	43
INFILTRATION	X		X	92
			TOTAL:	

SAMPLE DATA SHEET #2

Inches of Insulation		Total Heat Loss Rate in BTU/Hr °F (from Data Sheet #1)	Corrected Heat Loss (+ 10% Error)	Heat Loss Per Day °F (X 24 hours)	Total BTU Heat Loss Per Year (X total HDD)	Gallons of Oil Consumed Per Year (÷ by 145,000 BTU's/gallon)	Yearly Cost of Heating (X price/gal.)
Wall	Ceiling						
0"	0"						
0"	3"						
0"	6"						
0"	12"						
0"	18"						
3"	0"						
3"	3"						
3"	6"						
3"	12"						
3"	18"						
6"	0"						
6"	3"						
6"	6"						
6"	12"						
6"	18"						

9. Total Heat Loss per Year.

This depends on the yearly total of heating degree days for your area. This information can be obtained from your teacher or from a local energy supplier. (i.e., fuel oil dealer, natural gas dealer).

Heating degree days accumulate only when the outside temperature drops below 65°F. It is implied that heat for a house is only required when the outside temperatures are below 65°F. Heating degree days can be determined by using the following method. Take the high and low temperature for a given day and determine the mean temperature.

High temperature 70^{o}
Low temperature $+30^{o}$

$2\overline{)100} = 50^{o}$

Mean temperature is 50^{o}F

Next subtract the mean temperature for that day from the base of 65^{o}F.

65^{o}
-50^{o}

15 heating degree days

This can be calculated for every day of the year.

Total BTU heat loss per year = BTU/day ^{o}F x total heating degree days for the year.

For example:

10,138 BTU/day ^{o}F x 7223 heating degree days = 73,226,774

Total heat loss of 1976 = 73,226,774 BTU

Now calculate the total heat loss per year for the various combinations. THIS SHOULD BE DONE FOR YOUR AREA AND FOR ANY OTHERS THAT YOU CHOOSE. PLACE YOUR DATA IN THE APPROPRIATE COLUMN ON DATA SHEET 2.

10. Gallons of Oil Consumed per Year.

The BTU equivalents for the most common fuels are given in the following chart.

145,000 BTU = 1 gallon oil
1,000 BTU = 1 cubic foot natural gas
3,412 BTU = 1 kilowatt hour of electricity

Calculate how many gallons of oil are needed to heat this house for a year for each combination of insulation on Data Sheet 2. Place your calculations in the appropriate column on Data Sheet 2.

11. Yearly Heating Costs.

Using the present price for oil, calculate the yearly cost of heating the house for each combination of insulation. Place these calculations in the appropriate column on Data Sheet 2.

Oil price/gal. x gallons of oil consumed per year = yearly cost of heating.

12. Graphing the Data.

So far you have accumulated large amounts of data. By graphing these data, you can observe some relationships and trends. Graph the amount of ceiling insulation against the yearly heating cost for each thickness of wall insulation. The graph should consist of three lines: one line for 0" wall insulation, one for 3" wall insulation and one for 6" wall insulation.

LOOKING BACK

You have now determined the total annual heat loss of a typical one-floor house situated in your area of the country. The annual cost to heat this house using varying amounts and combinations of insulation in the walls and ceilings has been determined and graphed. By now, you should also be able to see the effect of insulation on both heat loss and the cost of heating a house.

QUESTIONS

1a. What would be the annual cost of heating this typical house when it has 3" insulation in the walls and 3" insulation in the ceiling?

b. If you added 3 more inches of insulation to the ceiling, how much money would you save annually in oil heating bills?

c. If you added 3 more inches to that, so that you now have 9" insulation in the ceiling, how much would you save in annual oil heating bills as opposed to having 6" insulation in the ceiling?

2. According to your graphs what would be the annual heating costs of the home with no insulation? With maximum insulation in walls and ceiling?

3. If you could only insulate either the ceiling or the walls with the same thickness of insulation (disregarding the cost of insulation), which would save you more money on your heating bill? Why?

GOING FURTHER

- Using the costs of insulation for your area, determine how long it would take to pay back the cost of adding additional insulation through savings in oil heating bills. This can be done for any number of situations. For example:

  a. A house with 3" wall insulation and 3" ceiling insulation has 6" insulation added to the ceiling.

  b. A house with 3" wall insulation and 6" ceiling insulation has 6" insulation added to the ceiling.

  c. A house with 0" wall insulation and 3" ceiling insulation has 3" wall insulation added.

- You are constructing a new house with the same dimensions as the house in the activity with 6" insulation in the ceiling and want to use 2" x 6" wood rather than conventional 2" x 4" S to build your walls. This type of construction would allow you to put 6" insulation in the walls rather than 3" insulation. How long would it take to pay back the cost of the additional insulation in the walls through savings in oil heating bills? Remember to include the additional costs of 2" x 6" s vs. 2" x 4" s in your calculations. You can assume that on the average 2" x 4" s are 16" apart and 2" x 6" s are 24" apart.

- New types of insulation have been designed with an R value of roughly 38. These rigid materials can be used to make the walls and also provide support. If our typical house were constructed of this type of material, what would be its annual oil heating cost?

- Determine the annual heating costs for varying thicknesses of insulation if our typical home were heated by gas or electricity. Which type of fuel seems most economical? Consult power companies in your area to find the cost of gas or electricity. (See table in step 2.)

- Try using your own home as a model and determine its annual heating cost. Compare your computations to the actual heating bills. If you live in a two story home or a home with a basement, the values for heat loss will vary.

Teacher Information Sheet

THE EFFECTS OF INSULATION ON HOME HEATING COSTS

Suggested Grade Level and Discipline

11-12 Grade Science
Advanced 9th and 10th grades

Background Information

Detailed background information is given in the student section of this activity. Additional information is available in the references.

Hints on Gathering Materials

- Graph paper and a calculator are needed.
- Heating degree days data for your area can be obtained from local heating fuel dealers.
- Costs of insulation can be obtained from local home insulators or building supply stores.

Suggested Time Allotment

- Two or three days of 42 minute class periods are appropriate, depending on how far in depth the teachers wishes to go with the questions. Some of the GOING FURTHER activities would require using additional time.

Suggested Approach

- This activity could be part of a unit on solar energy or part of any unit in a course which studies energy conservation. This activity also could be part of a consumer economics course.
- Time spent on the activity could be reduced by assigning different groups of students to complete the data for different insulating conditions, and then allowing them to share their data. But each student should make his own graphs in order to see the various relationships for himself.
- The topic of insulation offers a unique opportunity to infuse career education into the classroom, since it is a good example of the new kinds of career opportunities suddenly opening up in the energy-environment field. Insulation contracting has sprung up overnight in the face of

energy cost increases. Insulation contractors and experts could be brought into the classroom to discuss their new lines of work, or students could go out into the community to interview them and observe their jobs. Power company consumer representatives could be brought in to discuss their jobs, as well as their companies; recommendations for home insulation.

- This activity could be done as a student project or taken home.

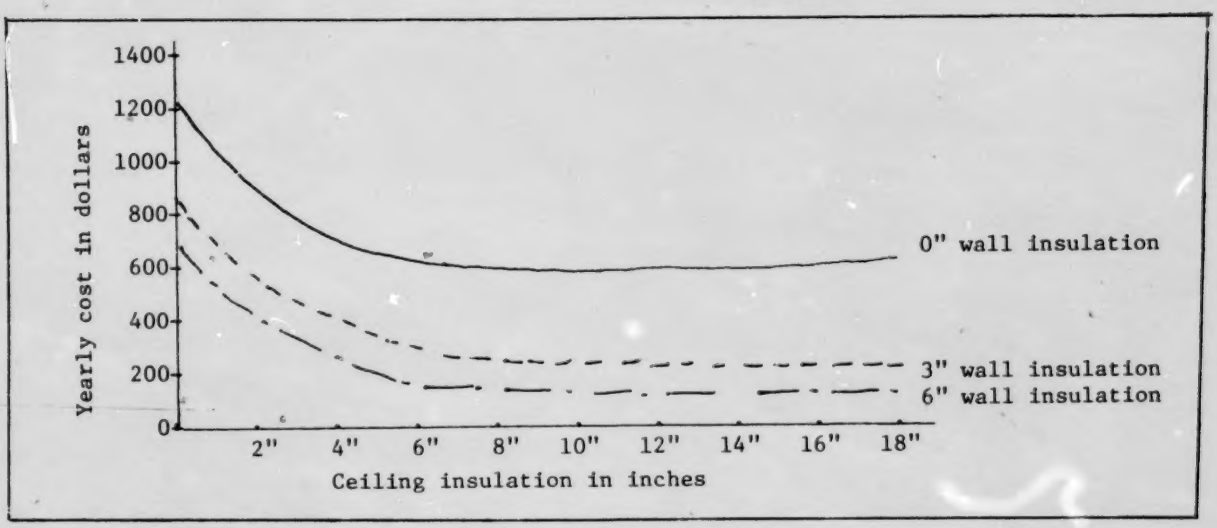
Typical Results

- Refer to the graph below for typical results in the northeast. When computing yearly BTU's the category 0" ceiling insulation and 0" wall insulation will probably yield a number larger than a hand calculator is capable of computing. It will probably be necessary to use some other type of calculator for calculations involving the use of 0" insulation.

- Typical results for the Data Sheet are:

  (0" wall and 0" ceiling):

  - Total Heat 1055-1559.
  - Corrected Heat 1055-1715.
  - Heat loss per day = 41,160.
  - Total BTU loss per year = 297,298,680.
  - Gallons oil consumed = 2973 gallons.



Precautions

- *To complete Data Sheet 2, you must have Heating Degree Days data for your own area. Substitute these data in step 9 of* METHOD. *(See* HINTS ON GATHERING MATERIALS.*)*

Modifications

- This activity could be shortened by omitting some of the categories in Data Sheet 2. The category of 0" wall and 0" ceiling insulation should not be excluded since it dramatically indicates the large heating costs that result.

Evaluation

- Students should be able to discuss the relationship of varying thicknesses of insulation to the costs of home heating. Students should be able to draw conclusions concerning the value of insulation and the amounts needed in a home. The sections QUESTIONS and GOING FURTHER of the Student Activity should be useful in determining student understanding of the topic. Graphs should be correctly made and analysis of the graphs well-thought out.

References

- *Heating Degree Days*, Ray Falconer, (Atmospheric Sciences Research Center, State University of New York at Albany, Publication No. 432).

- *Other Homes and Garbage: Designs for Self-Sufficient Living*, Jim Lackie, Gil Master, Harry Whitehouse, and Lily Young, (Sierra Club Books, San Francisco), 1975.

287-000 O - 79 - 3

HOME ENERGY USE

INTRODUCTION

Do you know how much energy is used in your home in one day? Do you know where this energy comes from? Knowing the answers to these questions can help you understand both the importance of energy in your daily life and the problem of energy conservation in your home.

In this activity you will measure the energy used in your home. You will collect data that will show you <u>when</u> your family uses most of its energy and <u>how</u> it uses this energy. With this information you can begin to examine ways for your family to conserve energy. Would your family members be willing to change the way they live in order to conserve energy? Would they spend money on energy conservation? Have your family members already begun to change the way they live to save on energy costs?

OBJECTIVES

At the completion of this activity you should be able to:

- o recognize and understand the units in which energy is measured.
- o read electric and/or gas utility meters.
- o determine how much energy your family uses in a two month period.
- o determine for what purposes various amounts of energy are used in your home.
- o calculate heating degree days.
- o recognize the types of systems used to produce heat and hot water.

SKILLS AND KNOWLEDGE YOU NEED

- How to do basic arithmetic.
- How to graph data.
- How to keep a daily journal.

MATERIALS

- A notebook.
- Access to utility meters in your home.
- Utility bills (optional, with your parents' consent).

METHOD

1. For the next two months keep a <u>daily</u> record of the information below in your notebook/journal.

   a. Weather conditions, including:

      - temperature (high and low)
      - wind
      - heating degree days
      - cloud cover or approximate hours of sunshine

   b. Utility meter readings (See practice worksheet for help in reading meters.)

c. The pattern of energy use in your home, such as:

- thermostat setting
- number, wattage, and length of time electric lights are on
- length of time electric appliances are run
- number of showers and baths

d. Any change in the pattern of home energy use such as a new stove, a refrigerator, or an additional television.

2. At the same time, keep a weekly record of the information below. Use only that information which is appropriate to your home.

a. fuel oil consumption

b. bottled gas consumption

c. wood consumption

3. Place your home's weekly energy data in the appropriate column on the next page.

CF = cubic feet (of natural gas)
KWH = kilowatt hours of electricity
BTU = British Thermal units of heat energy
LP = pounds of liquid propane (bottled gas)

4. To complete the table you must convert the amount of each kind of energy used to BTU's. The following chart provides the energy equivalents.

1 KWH = 3,413 BTU's
1 gallon #2 fuel oil = 145,000 BTU's
1 CF = 1,031 BTU's
1 lb. bottled gas = 21,700 BTU's
1 cord of wood = approximately 21,000,000 BTU's for hardwood, 13,000,000 BTU's for softwood

5. Record the weekly summary of energy use in a graph. Plot week versus total BTU's. Compare your results to the results of other students in the class.

6. Construct separate graphs, in the same way as the one above, of the total weekly energy use in BTU's for each energy source. Compare these graphs to one another and to those of other students in the class.

7. Construct a graph of total heating degree days for each week. Compare these graphs to the others you have constructed. Your teacher will instruct you how to find the heating degree days.

WEEKLY HOME ENERGY USE

Week	Dates	CCF	BTU's	Fuel Oil (gallons)	BTU's	LP (lbs.)	BTU's	KWH	BTU's	TOTAL BTU's
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

8. (optional) With your parents' permission, keep a monthly record of the amount of money spent on each kind of energy used. If you have data for several months, construct a graph of amount spent versus month.

LOOKING BACK

You have kept a daily journal of your family's energy needs and use over a long period of time. This information should give you a good start towards understanding the importance of energy to your family's well-being. It should also help you understand the seriousness of our nation's "energy crunch", and perhaps it can help you determine ways in which your family can help to solve the problem of energy conservation.

QUESTIONS

1. According to your graph of total energy consumption, what conclusions can you draw about your home's total energy use over time?

2. Compare your individual graphs of energy consumption for electricity, fuel oil, natural gas, etc. to one another. What conclusions can you draw from the graphs about your energy use relationships?

3. In terms of total BTU's, which energy source supplies most of the energy needs in your home? For what particular purpose do you think most of this energy is used? Why?

4. According to your graphs, when was your home's energy use the greatest? What are some reasons for this?

5. According to your graphs, when was your home's energy use the least? What are some reasons for this?

6. What are some changes you think your family could make to reduce the amount of energy it uses?

GOING FURTHER

- With your family's agreement, implement a plan to reduce your energy requirements. Continue to record your energy use in your journal. After several weeks, compare these new data with your original energy data to see if your energy requirements actually were reduced.

- Expand your energy journal to include automobile and gasoline use. Keep track of all trips made by automobile in your family. Record the destination, miles, and the number of gallons of gasoline used. Determine the number of miles per gallon for each of your family's automobiles. Plan some conservation measures for automobile use.

- Determine whether part of your family's energy needs could be met by alternate means such as the installation of solar panels. Do research to find out such things as:

  a. Total BTU required for hot water and home heating.

  b. Solar panel output:

     - The number of solar panels required to meet your families' needs.

     - The cost of solar panels, including installation.

     - The life expectancy of solar panels.

  c. Compare the above yearly cost for solar energy with your fuel costs. Include an inflation factor in your calculations.

  d. Would it be worthwhile to install solar panels in your home?

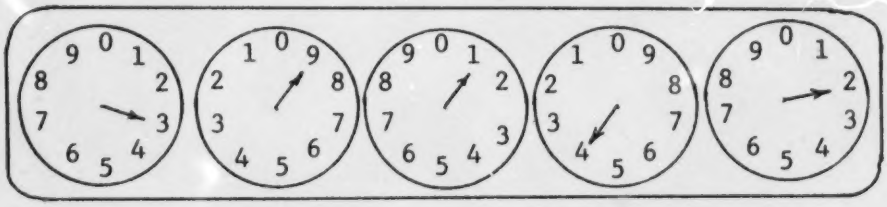
- Do an energy survey of your school. Follow the same steps as you used when surveying your home.

PRACTICE WORKSHEET

READING AN ELECTRIC METER

Electrical meters measure electricity in Kilowatt-hours (KWH). The meters are usually read monthly (or bimonthly) by a representative from your local electric company, so that the company knows how much to bill you for your electric use.

To learn how to read an electric meter yourself, look at the sample meter shown below.



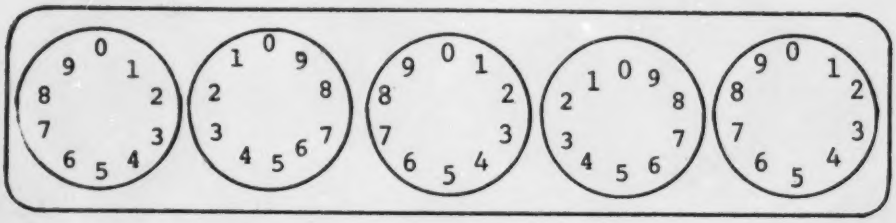
Notice that some of the dials read clockwise and some read counter-clockwise. Start at the left and read the number to which the needle points. If the needle is between two numbers, take the reading of the lower number.

What is the number of kilowatt-hours shown on the dial above?

_____ _____ _____ _____ _____ KWH

Now take the next page home with you and fill in the blank dials with the reading from your own electric meter. If your meter is different than the one shown, carefully copy the dials from your meter exactly as they appear, and then draw each needle on the dial as it appears on your meter. (Do this on a separate sheet of paper.)

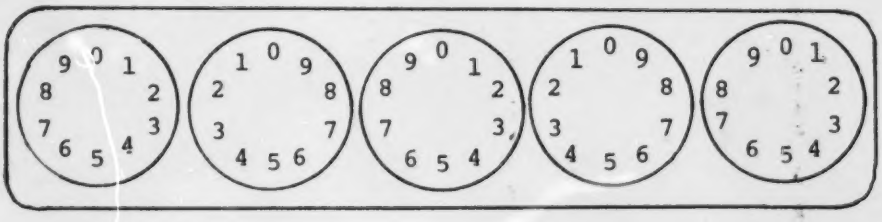
Then read your meter again one day later. Try to read the meter at the same time as the day before.



DATE: _____

TIME: _____

METER READING #1 _____KWH



DATE: _____

TIME: _____

METER READING #2 _____KWH

If you subtract meter reading #1 from meter reading #2, you will know how much electricity your home used in one day.

Meter reading #2 = _____KWH

Meter reading #1 = _____KWH

(subtract) _____KWH = your electric use for one day

Teacher Information Sheet

HOME ENERGY USE

Suggested Grade Level and Discipline

9-12 Physical Science
Earth Science, Advanced Junior High School
Consumer Education, Human Ecology
Math
Adult Education

Background Information

Most families use more than one kind of energy to meet their home energy needs. Common combinations include natural gas and electricity, fuel oil and electricity, or some combination with bottled gas; although newer homes may be all-electric, and wood increasingly is being used as an auxiliary energy source. Since these kinds of energy are commonly measured in different units, it becomes a problem to compare the proportion of energy used among the different sources. This problem can be solved by converting each energy unit to a single common unit.

The most common unit for measuring heat energy is the British Thermal Unit (BTU). It is defined as the amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit from 39°F to 40°F. Most engineering work is done in BTU's as is the output rating of most heating systems. Therefore, students are given the energy equivalents to convert each kind of energy to BTU's, so that they are able to compare data.

The common units of energy use are:

kilowatt-hour for electrical use
cubic foot for natural gas
gallon for fuel oil
pound for bottled gas (LP)
cord for wood (A cord is a stack of wood measuring 4' x 4' x 8', or 120 cubic feet of wood. This is an inexact unit.) This is a full cord, a face cord consists of a pile 1/3 the size of a full cord.

If you prefer to use a metric unit for energy use, then the standard unit for heat is the calorie, although the kilocalorie is commonly found in the literature. A calorie is defined as the amount of heat necessary to raise the temperature of one gram of water one degree Celsius, from 14.5°C to 15.5°C. A kilocalorie is 1,000 calories. The conversions to kilocalories for each kind of energy are:

1 kilowatt-hour = 860.1 kilocalories
1 gallon #2 fuel oil = 43,776 kilocalories
1 cubic foot natural gas = 259.8 kilocalories
1 pound bottled gas = 5,465 kilocalories
1 cord wood = 5,289,673 kilocalories for hardwood
3,274,559 kilocalories for softwood

NOTE: for all woods BTU's per pound = 5,790; kcal per pound = 1,459

To help you understand what this answer means, 1 kilowatt = 1,000 watts. Therefore, 1 kilowatt-hour is equal to ten 100-watt bulbs burning for 1 hour.

NOTE: Look for a meter-multiplier on all meters. Some electric meters may only have 4 dials. These meters should have a meter-multiplier factor of 10. The meter should state on it (x 10). If this is so, then the number read from the dials must be multiplied by 10 to arrive at kilowatt hours.

If you have a gas meter, it is read in essentially the same way, except that the smallest quantity of gas measured by most gas meters is 100 cubic feet. Therefore, gas meter readings must be multiplied by 100 to arrive at cubic feet.

Since space heating tends to be a major use of energy in the home, the concept of heating degree days can be helpful in a survey of home energy use. The number of heating degree days is a measure of the amount of heat that will be needed for space heating purposes. Comparison of heating degree days from week to week or month to month can help to determine the proportion of energy used for space heating.

Heating degree days (HDD) are calculated in the following way:

1. In general heat is not required when the mean $\frac{(\text{high} + \text{low})}{2}$ outdoor temperature is $65^{\circ}F$ or above.

2. The formula for heating degree days for a given day is $65^{\circ}F$ minus the mean outdoor temperature. For example, on a given day, if:

   the high = $40^{\circ}F$
   and the low = $20^{\circ}F$
   then the mean = $\frac{40 + 20}{2} = 30^{\circ}F$

   thus, heating degree days = 65 - 30 = 35.

3. Total HDD over a period of time are found by adding the results for each day.

Heating degree day information may be obtained from a local weather station, a local oil dealer, or your gas and electric company.

Hints on Gathering Material

- Announce in advance of the activity that a notebook will be needed for keeping a journal.
- If possible, obtain a gas or electric meter to use as a classroom demonstrator. Contact your local utilities.
- The Data Table for energy use can be duplicated and handed out to students as the activity begins. (If wood is used as an energy source, it must be added to the table.)

Suggested Time Allotment

- Introduction of the activity, including an explanation of journal keeping, of units of energy, and of heating degree days; 1 class period.
- Use of the practice worksheet on reading meters; part of 2 class periods by 1 day.
- Part of one class per week to work on the journal, to record data, and to work on converting energy units.
- One to two class periods to prepare graphs. (Some of this could be done as homework assignments.)

- One to two class periods to compare and discuss differences among student graphs, to discuss possible reasons for the differences, and to discuss energy conservation methods and their possible effects.

Suggested Approach

- The length of time devoted to journal keeping may vary depending on the interest level of the students.
- Parts of the activity may be used, depending on the ability and interest levels of the students.
- Carefully introduce the concept of journal-keeping if students have not been exposed to it before.
- Discuss energy units and heating degree days as the activity is introduced.
- The practice worksheet on meter reading can be used at the start of the activity to insure that students are able to read their utility meters.
- Demonstrate making energy conversions to BTU's and allow for practice time in making conversions.
- Give students help in plotting data on graphs.
- For career and consumer education infusion, representatives from the energy field may be invited into the classroom to discuss various aspects of the activity. An electrical utility representative can discuss how electrical energy is used in the home. A fuel oil distributor could discuss his company's relationship to home energy use. Individuals involved in energy conservation could discuss conservation measures such as auxiliary heating with wood, solar heating, insulation, etc.

Typical Results

- Results will vary depending on geographic location and time of year.
- Results will also vary depending on the source of energy used for space heating. Depending on geographic location, electricity, fuel oil, or natural gas will be used for space heating.

Precautions

- *Some students may not have access to utility meters, especially if they live in apartment houses.*
- *Some parents may regard this activity as an invasion of privacy. A statement to parents of the activity's purpose, along with permission slips to be signed by parents, is suggested.*

- *Not all utility meters are alike. Contact your utility company for the kind of meters used in your locality.*

- *Student interest may lag during a long-term investigation such as this; therefore a weekly update session may be important.*

Modification

- Keep a record of the energy consumed by the school. Could conservation methods be practiced here?

Evaluation

- Observe your students' ability to keep daily journals as the activity progresses.

- Collect and review the data gathered by each student. Was the data table carefully and correctly filled in? Were the graphs well-organized and usable for data analysis?

- Are the answers to the questions requiring analysis of the graphs well thought out?

References

- *Save Energy, Save Dollars,* Efficient Energy Management for Consumers (Cornell University, Ithaca, New York. Bulletin 125. $1.50)

- *Heating Degree Days,* Ray Falconer. (Atmospheric Sciences Research Center, State University of New York at Albany. Publication No. 432).

- *Energy Conservation, Homes & Buildings.* National Science Teachers Association, Factsheet #9. (Available from the Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830).

- *Kill A Watt,* Award Winning Energy Education Activities. National Science Teachers Association. (Available from the Department of Energy, Technical Information Center).

- *Your Energy Efficient House,* A. Adams. (Charlotte, Vermont: Garden Way Publishing Co.)

SOLAR ENERGY IN A MAGAZINE

INTRODUCTION

With the need for alternate energy sources becoming more noticeable and desirable every day, an obvious source is the sun. What needs do we have as far as energy is concerned? How can solar energy fit these needs? What research and development has been done in the area of solar energy? Most of the recent work is too new to be found in textbooks but is instead found in various magazine articles. In this activity you will be using your library to find some of this information.

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OBJECTIVES

This research should enable you to:

- o find and list the available sources of information regarding solar energy.
- o see what has been done in the area of solar energy research and development.

SKILLS AND KNOWLEDGE YOU NEED

- How to use the library resources, especially the Reader's Guide to Periodical Literature.

MATERIALS

- Library resources.

METHOD

1. From the Reader's Guide or other library references, find and list the articles or books concerning the energy crisis, sources of energy, and solar energy. Use one or more of the data sheets to record this information.
2. Using your list, find as many of these articles as possible. Read five of them and note the important parts on a separate sheet of paper. While doing this keep in mind that the material could be used for general discussion by all the class. If a source is not available, also note this on your data sheet.

LOOKING BACK

The information you have collected will serve as a reference to you, your class and your teacher in studying solar energy. It will also serve as a bibliography for your own research of solar energy. The sources which you could list, yet not find in your library, may be available in other libraries such as county, regional or even state libraries.

QUESTIONS

1. Which magazine or reference do you think contains the best article on solar energy?
2. Were there any magazines or references that were too difficult for you to read?
3. Based on your research, how important is solar energy as a future energy source?

GOING FURTHER

- Write a research paper on some aspect of solar energy.
- Try to obtain additional information on solar energy from such sources as the government, utilities, industries, or businesses.
- Try to obtain some of the sources not available in your library.

LIBRARY RESOURCE LIST DATA SHEET

TITLE OF THE ARTICLE OR REFERENCE	AUTHOR IF INDICATED	MAGAZINE OR OTHER REFERENCES	VOL./ISSUE	DATE	PAGES	WHERE AVAILABLE

Teacher Information Sheet

SOLAR ENERGY IN A MAGAZINE

Suggested Grade Level and Discipline

7-12 Science
(Actually can be used with almost any discipline.)

Background Information

This country is facing a possible energy crisis in the near future. The costs of energy sources are continuously rising as their supply is decreasing. The natural gas shortage in the winter of 1977 led many people to realize that we must begin to search for alternate energy sources. One of these sources is solar energy.

It is very important that all citizens be made aware of all the possible energy sources. This education can begin in the schools. Therefore, in this activity, students are going to make optimum use of the library facilities in order to determine what alternatives we have in the energy field. They will especially concentrate on solar energy. Since most information on solar energy is of a recent nature, students will be directed to make particular use of magazine articles and pamphlets.

Hints on Gathering Materials

- Prior to this activity (if it requires budgetary allotments this could be as far as a year in advance) the teacher should:

  a. Check the availability of magazines such as Popular Science, Popular Mechanics, U.S. News and World Report, etc.

  b. Coordinate with the librarian the use of facilities, microfilm readers, etc., perhaps having the librarian review library procedures.

Suggested Time Allotment

- This can vary from 2 days to 1 week.

Suggested Approach

- This activity can be used as an introduction to a unit on solar energy.
- Check the student's ability to use various library resources such as the card catalogue and Reader's Guide to Periodical Literature. If any students are deficient in these skills have the librarian give them adequate instruction.

- Students should work individually.
- Students should begin to list on their data sheets the sources of information on solar energy.
- The students are then to check whether the magazine or source listed is available in their library. If not, they should try to determine where they may find it.
- The student should read the article or source material and make notes as to its content, its readability, etc. (Some articles may be too technical or too difficult for this particular class.)
- Check library resources prior to this assignment. Many articles may be listed but few actually available.
- Students should be checked on the use of micro-film by the librarian prior to using equipment.
- Insure that there are enough Readers' Guides for the number of students using them.

Typical Results

- Depending on the source material available, the student will have an extensive bibliography as a supplement for his solar energy work.

Precautions

- *None*

Modifications

- This activity may be used to extend into alternate energy sources, e.g., wind, water, geothermal.
- This activity may be used as preparation for writing a research paper.

Evaluation

- Check the students' answers to the questions and also check their data sheet.

TRACKING THE SUN BY COMPUTER

INTRODUCTION

How can you get your solar collector to follow the sun? Where is the sun on a cloudy or hazy day?

Knowing the position of the sun is essential to solar energy experiments. The sun is more or less constant in its output of energy. The amount of energy which is available for use varies due to several factors. One of the most important is the sun's changing position in the sky. This activity will allow you to find the sun's position in the sky at various latitudes and times of day using a computer.

OBJECTIVES

At the completion of this activity, the student should be able to:

- o find the altitude and azimuth of the sun for any date, location and time.
- o find the right ascension and declination of the sun for any date, location and time.
- o by use of the computer visually display a diagram of the sun's position for any date, location and time.

SKILLS AND KNOWLEDGE YOU NEED

- How to use a computer terminal.
- A knowledge of your local time zone.
- A knowledge of your longitude.
- A knowledge of your latitude.
- A knowledge of altitude, azimuth, declination and right ascension.

MATERIALS

- A computer terminal.
- Sun position computer program included in this activity.

METHOD

1. Be sure to follow all instructions exactly as stated by the computer program. Your teacher will give you a set of instructions.

LOOKING BACK

This program gives you the position of the sun in two systems: Right ascension and declination, and altitude and azimuth. If this information is to be used to align a collector, right ascension and declination could be used for a movable collector mounted on an equatorial mount. Altitude and azimuth can be used for simpler mounts or fixed collectors.

QUESTIONS

1. How could this information about the sun be used in the placement of solar collectors?

2. What are the astronomical changes that take place to cause the variations in the sun's path?

3. What effect does the sun's changing position have on the effectiveness of a solar collector?

GOING FURTHER

- Additional informational programs about the sun could be developed, such as: a) A program to compute the duration of sunlight on a given day at a given latitude. b) A program to compute the effectiveness of a collector in a fixed position, as the sun moves along it's daily path, and during the sun's change in position during the year.

Teacher Information Sheet

TRACKING THE SUN BY COMPUTER

Suggested Grade Level and Discipline

9-12 Earth Science
Astronomy
Computer Science

Background Information

This computer program was devised by high school students to find answers to their questions about the sun's apparent movements. A knowledge of mathematics, computer science and astronomy was necessary to devise this program. This knowledge then had to be integrated into a scientific tool. This tool could then be used in solving solar energy problems.

The students who devised this program know that the effectiveness of a solar powered device depends on its alignment to the sun. If a collector is properly aligned its effectiveness could be greatly increased. Therefore they wanted to find the sun's exact position. They knew that this position can easily be found by looking in the nautical ephemeris, but in devising a computer program many valuable lessons were learned.

This program can be used as an end in itself or as a stimulus toward the development of more solar information programs.

Hints on Gathering Materials

- Whenever devising a computer program decide if it serves a purpose and is applicable to the needs of the unit being studied.
- A flow chart from which this program was developed is available from the Solar Energy Education Project, c/o Bureau of Science Education, State Education Department, Albany, New York, 12234.

Suggested Time Allotment

- If the program is to be used as an informational gathering tool it could be completed in five minutes.
- If the program is to be used as a stimulus to the development of further programs the time allotment could be several weeks.

Suggested Approach

- The program must be entered into the schools own data storage system and therefore a program list has been supplied. The program is written in Hewlett-Packard Basic 2000 Level F.
- Before beginning, students should be adequately instructed in the method of getting this program on the computer and told to follow carefully all instructions, given by the program.

```
RUN
SUN
THIS PROGRAM WILL ALLOW YOUR TO CALCULATE THE RIGHT
ASCENSION, DECLINATION, ALTITUDE, AND AZIMUTH OF THE SUN
ON A GIVEN DATE
THE AZIMUTH OF THE SUN RUNS FROM 0 DEGREES AT THE SOUTH
TO 90 DEGREES AT THE EAST TO 180 DEGREES AT THE NORTH
TO 270 DEGREES AT THE WEST

WHAT IS YOUR LATITUDE IN DEGREES(+ FOR NORTH, - FOR SOUTH)?40

WHAT IS YOUR LONGITUDE IN DEGREES(+ FOR WEST, - FOR EAST)?72

TO FIND THE DESIRED INFORMATION     *     INPUT
IN THIS TIME ZONE                   *     THIS
*************************************************
GREENWICH MEAN TIME                 *     GREENWICH
EASTERN STANDARD TIME               *     EST
CENTRAL STANDARD TIME               *     CST
MOUNTAIN STANDARD TIME              *     MST
PACIFIC STANDARD TIME               *     PST

WHAT IS YOUR TIME ZONE?EST

INPUT THE DATA IN THE FOLLOWING FORM
INPUT THE MONTH(1-12), A COMMA, THE DAY(1-31),
A COMMA, AND THE YEAR(ALL 4 DIGITS)?6,22,1492

INPUT THE TIME OF DAY IN THE FOLLOWING FORM
INPUT THETIME ON THE INTERNATIONAL CLOCK (0-24)
THE TIME MUST BE INPUT IN DECIMAL FORM?5.25

THE DECLINATION OF THE SUN IS 23    DEGREES
THE RIGHT ASCENTION OF THE SUN IS 6.3     HOURS
THE ALTITUDE IS 15    DEGREES
THE AZIMUTH IS 108   DEGREES
                              ZENITH
                                 *     *     *
                           *                       *
                     *                                   *
                 *                                             *
             *                                                       *
          *                                                             *
       *                                                                   *
    *                                                                         *
 *                                  0                                          *
      (S)                          *I*
                                  * I *
                                  * *
*                                 *   *                                       *
*************************************************************************************
 I          I                     I                          I          I
 I          I          .          I                          I          I
 NE         E                     S                          W          NW
```

Typical Results

- See previous page.

Precautions

- *The computer must be programmed exactly according to the accompanying program.*

Modifications

- The program may be modified to include additional astronomical motions.

Evaluation

- NONE

LIST
SUN

COMPUTER PROGRAM

```
1000  REM **** PROGRAMED BY MICHAEL D. ANGLE ****
1010  REM **** WRITTEN IN HEWLETT-PACKARD BASIC 2000 LEVEL F ****
1020  PRINT "THIS PROGRAM WILL ALLOW YOU TO CALCULATE THE RIGHT"
1030  PRINT "ASCENSION, DECLINATION, ALTITUDE, AND AZIMUTH OF THE SUN"
1040  PRINT "ON A GIVEN DATE"
1050  PRINT "THE AZIMUTH OF THE SUN RUNS FROM 0 DEGREES AT THE SOUTH"
1060  PRINT "TO 90 DEGREES AT THE EAST TO 180 DEGREES AT THE NORTH"
1070  PRINT "TO 270 DEGREES AT THE WEST"
1080  PRINT
1090  DIM A$[9],F$[1],T$[9]
1100  LET A=.91706
1110  LET Z=.017202
1120  LET Z1=57.2958
1130  LET Z2=.017453
1140  LET P1=3.14159
1150  PRINT "WHAT IS YOUR LATITUDE IN DEGREES(+ FOR NORTH, -FOR SOUTH)";
1160  INPUT L1
1170  LET L1=L1*Z2
1180  PRINT
1190  PRINT "WHAT IS YOUR LONGITUDE IN DEGREES(+ FOR WEST, - FOR EAST)";
1200  INPUT L2
1210  LET L2=L2/15
1220  PRINT
1230  PRINT "TO FIND THE DESIRED INFORMATITON      *      INPUT"
1240  PRINT "IN THIS TIME ZONE                     *      THIS"
1250  PRINT "*******************************************************"
1260  PRINT "GREENWICH MEAN TIME                   *      GREENWICH"
1270  PRINT "EASTERN STANDARD TIME                 *      EST"
1280  PRINT "CENTRAL STANDARD TIME                 *      CST"
1290  PRINT "MOUNTAIN STANDARD TIME                *      MST"
1300  PRINT "PACIFIC STANDARD TIME                 *      PST"
1310  PRINT
1320  PRINT "WHAT IS YOUR TIME ZONE";
1330  INPUT T$
1340  PRINT
1350  PRINT "INPUT THE DATE IN THE FOLLOWING FORM"
1360  PRINT "INPUT THE MONTH(1-12), A COMMA, THE DAY(1-31),"
1370  PRINT "A COMMA, AND THE YEAR(ALL 4 DIGITS)";
1380  INPUT D1,D2,Y8
1390  PRINT
1400  PRINT "INPUT THE TIME OF DAY IN THE FOLLOWING FORM"
1410  PRINT "INPUT THE TIME ON THE INTERNATIONAL CLOCK(0-24)"
1420  PRINT "THE TIME MUST BE INPUT IN DECIMAL FORM";
1430  INPUT T1
1440  PRINT LIN(2)
1450  RESTORE 2350
1460  READ A9,B9
1470  IF A9#D1 THEN 1460
1480  IF (Y8/4)#(INT(Y8/4)) THEN 1510
1490  IF D1 <= 2 THEN 1510
1500  LET B9=(B9+1)
1510  LET A3=Z*(B9+D2)
1520  RESTORE 2380
```

```
1530  READ A$,T9
1540  IF A$#T$ THEN 1530
1550  IF A3#0 THEN 1570
1560  LET A3=(A3+.00001)
1570  LET S1=(TAN(.410152)*(A^2/(A^2/ABS(TAN(A3))^2+1))^.5)
1580  LET D=ATN(S1/ABS(1-S1^2)^.5)*SGN(SIN(A3))
1590  LET D9=D*Z1
1600  LET D9=INT(D9+(.5*SGN(D9)))
1610  LET R=(ATN(TAN(A3)*COS(.410152)))/.261799+(SGN(COS(A3))-1)*-6
1620  LET R=(INT(R*10+(.5*SGN(R))))/10
1630  IF R >= 0 THEN 1650
1640  LET R=R+24
1650  PRINT "THE DECLINATION OF THE SUN IS"D9"DEGREES"
1660  PRINT "THE RIGHT ASCENTION OF THE SUN IS "R"HOURS"
1670  LET H=(((T1-12)+(T1-12)/360)*.261799-(L2-T9))
1680  LET S1=(SIN(D)*SIN(L1)+COS(D)*COS(L1)*COS(H))
1690  IF S1#1 THEN 1720
1700  LET A1=1.5708
1710  GOTO 1730
1720  LET A1=ATN(S1/ABS(1-(ABS(S1))^2)^.5)
1730  LET S1=((SIN(D)-SIN(A1)*SIN(L1))/(-1*COS(A1)*COS(L1)))
1740  IF S1#0 THEN 1770
1750  LET A2=90
1760  GOTO 1790
1770  LET A2=ATN(ABS(1-ABS(S1)^2)^.5/S1)
1780  LET A2=A2*Z1
1790  LET W=(T1-(L2-T9)/.261799)
1800  IF W >= 12 THEN 1840
1820  LET A2=180+A2
1830  GOTO 1880
1840  IF A2 >= 0 THEN 1870
1850  LET A2=180-A2
1860  GOTO 1880
1870  LET A2=360-A2
1880  LET A1=(A1*Z1)
1890  A1=(INT(A1+(.5*SGN(A1))))
1900  PRINT "THE ALTITUDE IS"A1"DEGREES"
1910  IF A1 <> 90 THEN 1930
1920  LET A2=0
1930  PRINT "THE AZIMUTH IS"(INT(A2+(.5*SGN(A2))))"DEGREES"
1940  IF A1>0 THEN 1970
1950  PRINT "THE SUN IS BELOW THE HORIZON"
1960  STOP
1970  REM **** PICTURE PRINTOUT ****
1980  PRINT LIN(3)
1990  IF L1 <= 0 THEN 2050
2000  IF A2>135 THEN 2030
2010  LET X=INT((135-A2)/3.91304+.5)
2020  GOTO 2060
2030  LET X=35+INT((360-A2)/3.91304+.5)
2040  GOTO 2060
2050  LET X=INT((315-A2)/3.91304+.5)
2060  LET Y=INT(A1/4.28571+.5)
2070  IF A1#90 THEN 2090
2080  LET Y=35
2090  RESTORE 2410
2100  PRINT TAB(33)"ZENITH"
2110  FOR U=21 TO 1 STEP -1
```

```
2120  IF Y#U THEN 2140
2130  PRINT TAB(X-1)"(S);
2140  READ F1,F$
2150  IF F$="5" THEN 2200
2160  PRINT TAB(F1);
2170  IF (F1+1) >= (X-1) AND (F1+1) <= (X+1) AND Y=U THEN 2140
2180  PRINT F$;
2190  GOTO 2140
2200  PRINT
2210  NEXT U
2220  FOR U1=1 TO 71
2230  PRINT "*";
2240  NEXT U1
2250  PRINT " I"TAB(11)"I"TAB(35)"I"TAB(59)"I"TAB(69)"I"
2260  PRINT " I"TAB(11)"I"TAB(35)"I"TAB(59)"I"TAB(69)"I"
2270  IF L1<0 THEN 2300
2280  PRINT " NE"TAB(11)"E"TAB(35)"S"TAB(59)"W"TAB(68)"NW"
2290  STOP
2300  PRINT " SW"TAB(11)"W"TAB(35)"N"TAB(59)"E"TAB(68)"SE"
2310  STOP
2320  PRINT " ";
2330  GOTO 2140
2340  REM **** DAYS FROM MAR. 21 DATA ****
2350  DATA 1,-80,2,-49,3,-21,4,11,5,41,6,72,7,102,8,133
2360  DATA 9,164,10,194,11,225,12,255
2370  REM **** TIME ZONE MERIDIAN DATA ****
2380  DATA "GREENWICH",0
2390  DATA "EST",5,"CST",6,"MST",7,"PST",8
2400  REM **** PICTURE PRINTOUT DATA ****
2410  DATA 28,"*",35,"*",42,"*",0,"5"
2420  DATA 22,"*",48,"*",0,"5",0,"5"
2430  DATA 16,"*",54,"*",0,"5",0,"5",0,"5"
2440  DATA 9,"*",61,"*",0,"5",0,"5",0,"5"
2450  DATA 5,"*",65,"*",0,"5",0,"5",0,"5"
2460  DATA 3,"*",67,"*",0,"5",0,"5",0,"5",0,"5"
2470  DATA 1,"*",35,"*",69,"*",0,"5"
2480  DATA 34,"*",35,"I",36,"*",0,"5"
2490  DATA 33,"*",35,"I",37,"*",0,"5"
2500  DATA 34,"*",36,"*",0,"5"
2510  DATA 0,"*",33,"*",37,"*",70,"*",0,"5"
2520  END
```

PROGRAM ADDUNDUM

TRACKING THE SUN BY COMPUTER

The following changes for some of the attached program instructions are made to assist you in putting this exercise on your system.

The changes may have to be initiated because of the lack of standardization among BASIC compilers. Any changes suggested conform to the so-called Dartmouth Basic which is as close to being a standard as exists. Instructions for which no comments have been made are common to all BASIC compilers.

To assist you in putting this program on your system a standardized program map has been prepared to include many of the changes.

TABLE OF SUGGESTED CHANGES

1. Statement #(s) — Item

   1090 — DIM statement

   Comment: String variables are handled by two different methods depending on the compiler.

   a. As in this program, by defining the number of characters in the string variable.

      Example: DIM A$(9)- - -

      A$ is a string variable 9 alphanumeric characters long.

   b. By setting up an array (table) of a specified number of elements or locations.

      Example: DIM A$(9)- - - will create a string variable array A$ of 9 locations of a set length depending on the compiler.

      If your system does not handle strings by method (a.) above exclude this statement from the program.

2. Statement #(s) — Item

   1260 — PRINT

   Comment: If your system uses method (a.) as described immediately above, it is suggested that the following three changes be made in the program listing. (If your system uses Method (b.) ignore these changes).

```
1090  DIM A$(3),F$(1),T$(3)
1260  PRINT "Greenwich Mean Time     *GRE"
2380  DATA "GRE",0
```

3. Statement #(s) Item

1440	PRINT LIN(2)
1980	PRINT LINE(3)

Comment: An option for vertical spacing not available in most BASIC compilers. Use a separate PRINT statement for each line of vertical spacing desired.

```
Example:  1440  PRINT
          1441  PRINT
                "
                "
                "
```

4. Statement #(s) Item

1450, 1520, 2090 RESTORE 2380

Comment: An option not common to most compilers. Normally the computer places all of the numbers listed in all of the DATA statements into a combined list. The values contained in the DATA statements are placed in this combined list in order from left to right sequentially by the ascending DATA statement numbers.

Make the following changes to the program if this option is not available. (These changes incorporate numeric arrays to obtain the proper values for use in the program.)

```
1085  DIM M(12),Z(5)
1086  READ M(1),M(2),M(3),M(4),M(5),M(6),M(7),M(8)
1087  READ M(9),M(10),M(11),M(12),Z(1),Z(2),Z(3),Z(4),Z(5)
1260  PRINT "Greenwich Mean Time     *  1"
1270  PRINT "Eastern Standard Time    *  2"
1280  PRINT "Central Standard Time    *  3"
1290  PRINT "Mountain Standard Time    *  4"
1300  PRINT "Pacific Standard Time    *  5"
1330  INPUT T
1450  Omit
1460  LET B9 = M(D1)
1470  Omit
1520  Omit
1530  LET T9 = Z(T)
1540  Omit
2350  DATA -80,-49,-21,11,41,72,102,133,164,194,225,255
2360  Omit
2380  DATA 0,5,6,7,8
2390  Omit
```

Comment: If the "Picture Printout" portion of the program is to be used omit statement #2090.

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5. Statement #(s) Item

1470,1480,1540 etc. #(not equal to)

Comment: As the average keyboard does not contain a #, most BASIC compilers do not understand this symbol. Use a < > to replace the #.

6. Statement #(s) Item

1570,1580 etc. ⌒ as in ⌒2

Comment: Not a common exponentiation symbol. Use either a ↑ or **. Try the ↑ first.

7. Statement #(s) Item

1570,1580 etc. ⌒.5

Comment: In these statements the square root of various quantities are being determined.

Comment: This method is common to most BASICS. If it does not prove satisfactory try the SQR (square root) function.

8. Statement #(s) Item

1610 LET R = (ATN(TAN(A3 - - - - - - - - (COS(A3))-1) *-6

Comment: Most compilers will not allow two arithmetic operators to exit next to each other as is double underlined above. Put parentheses around the -6

Example: *(-6)

9. Statement #(s) Item

1940 IF A1 > 0 - - - -

Comment: If the "Picture Printout" portion of the program is to be excluded change this statement to IF A1 > 0 THEN 1960. (Don't forget an END statement.)

If it is desired to build a loop into this program so that the results of different input may be determined, it can be done at statement 1960 by asking this question with a PRINT statement, and using an INPUT and IF test.

10. Statement #(s) — Item

2170 — IF - - - AND

Comment: This option is not available in many compilers. Use the following:

```
2170  IF(F1+1) < (X-1) THEN 2180
2171  IF(F1+1) > (X-1) THEN 2180
2172  IF Y = U THEN 2140
```

11. Statement #(s) — Item

2290,2310 — STOP

Comment: If a loop is desired in this program including the "Picture Printout" portion, it can be done at these points by asking this question with a PRINT statement and using an INPUT and IF test. If it is done at this point also include a RESTORE and branch to statement 1086. (see #4).

STANDARDIZED PROGRAM MAP*

Statement #(s)	Changes (If any)
1000-1080	None
1085	DIM M(12),Z(5)
1086	READ M(1),M(2),M(3),M(4),M(5),M(6),M(7),M(8)
1087	READ M(9),M(10),M(11),M(12),Z(1),Z(2),Z(3), Z(4),Z(5)
1090	Omit
1100-1250	None
1260-1300	see TABLE OF SUGGESTED CHANGES #4
1310-1320	None
1330	INPUT T
1340-1430	None
1440	PRINT
1441	PRINT
1442	PRINT
1450	Omit
1460	LET B9=M(D1)
1470	Omit
1480-1510	None (change any # to <>)
1520	Omit
1530	LET T9=Z(T)
1540	Omit
1550	Change # to <>
1560	None
1570-1600	None (Change any ⌒ to ↑ or **)
1610	see TABLE OF SUGGESTED CHANGES #8
1620-1680	None
1690	Change # to <>
1700-1710	None
1720	Change to or **
1730	None
1740	Change # to <>
1750-1760	None
1770	Change to or **
1780-1930	None
1940	see TABLE OF SUGGESTED CHANGES #9
1950-1970	None
1980	PRINT
1981	PRINT
1982	PRINT
1983	PRINT
1990-2080	Change # to <>
2090	Omit
2100-2160	Change # to <>
2170	IF (F1+1) (X-1) THEN 2180
2171	IF (F1+1) (X+1) THEN 2180
2172	IF Y = U THEN 2140

2180-2340	None (see TABLE OF SUGGESTED CHANGES #11)
2350	DATA -80,-49,-21,11,41,72,102,133,164, 194,225,255
2360	Omit
2370	None
2380	DATA 0,5,6,7,8
2390	Omit
2400-2520	None

*NOTE See TABLE OF SUGGESTED CHANGES

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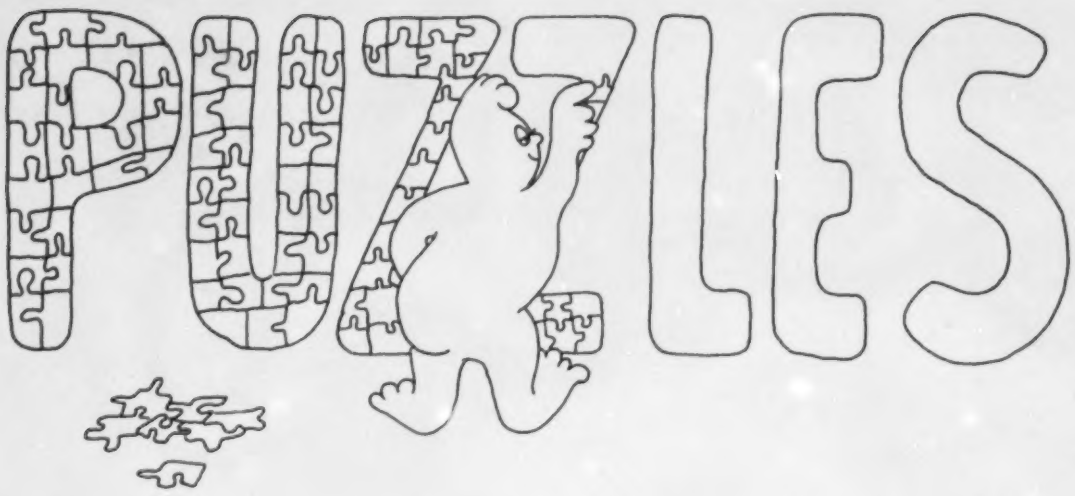


INTRODUCTION

Puzzles and games often provide a welcome relief from the concentration required by more comprehensive activities. Yet they also can provide opportunities for reviewing terms and concepts in new and provocative ways. Possible applications to solar energy are numerous.

The following exercises are grouped by type and indicate what might be attempted in your initial attempts to "tantalize". With practice, the efforts of both you and your students will become more elaborate and sophisticated.

Crossword Puzzles

Still to be considered worthwhile are the traditional cross-word puzzles using clues that relate to solar energy. Some teachers are extremely talented in the creation of such word patterns. But anyone is capable of producing simple patterns such as the one on the following page.

Word Searches

Students enjoy finding words related to solar energy hidden in a matrix of letters. Depending upon the difficulty of the vocabulary involved, the words may be provided or left for the students to discover themselves. The following word searches serve as examples: Solar Energy Puzzle, Solar Heat, Discovering the Sun, and Solar Energy Word Find.

Word Scrambles

Unscrambling words which become solar energy terms can be challenging to young people, especially when tied to other tasks, as indicated in the examples that follow: Solar Energy Quiz, and Jumbles.

Hidden Messages

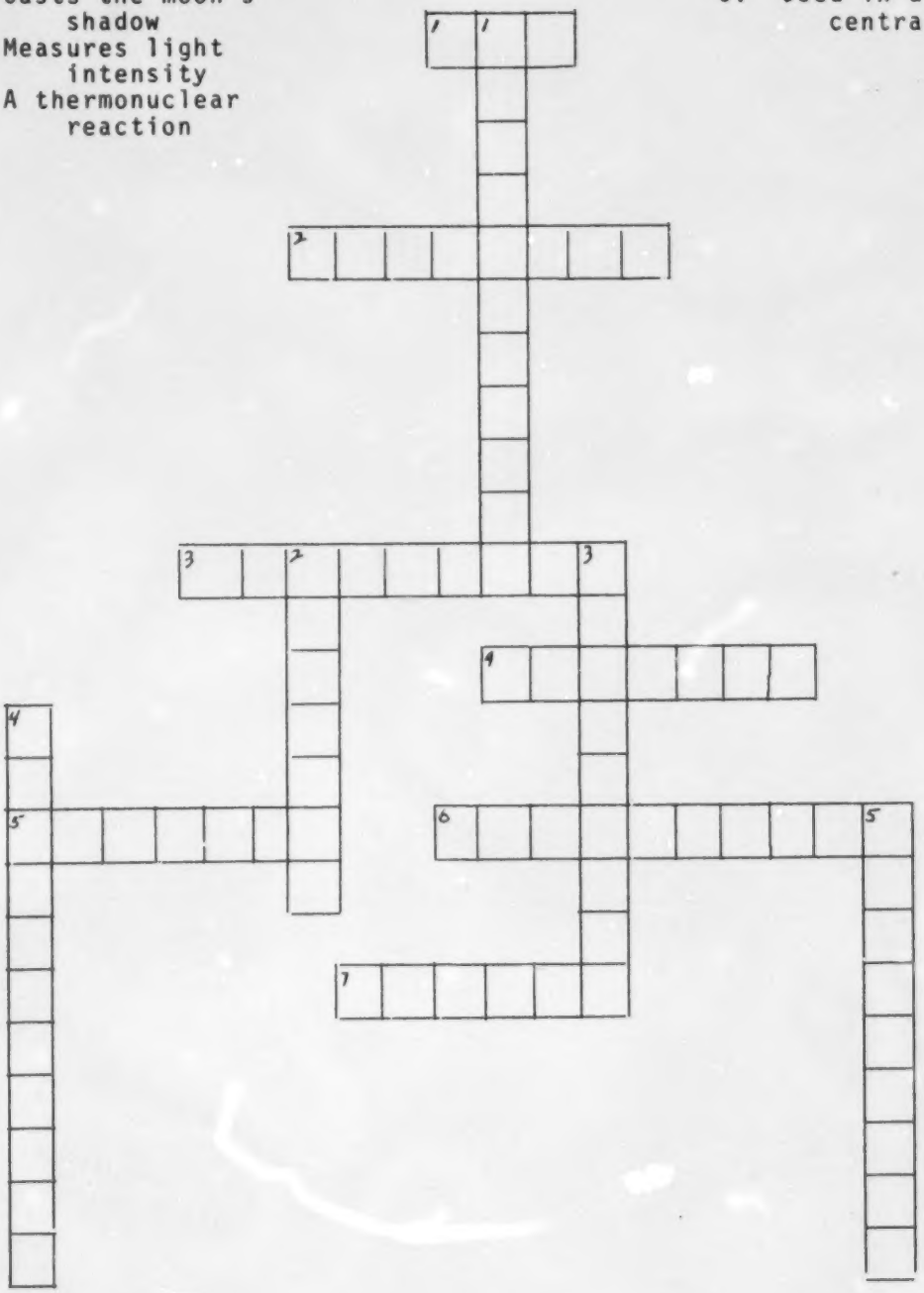
Word completion exercises that would otherwise be fairly routine can become more intriguing when they are designed to reveal a thought or feeling as illustrated in: A Solar Perspective.

Across

1. Our ultimate energy source
2. Heat radiation
3. Used for solar heating
4. An element in solar cells
5. Casts the moon's shadow
6. Measures light intensity
7. A thermonuclear reaction

Down

1. Shielded out by the earth's ozone layer
2. 1 cal/cm^2
3. Energy from the sun
4. Measures temperature
5. Used in a solar concentrator



SOLAR ENERGY PUZZLE

T H K L E N E R G Y A C Z S Q U L W X E K G T H L
L M S Q S M G P A L I M E X K I M J B D F I L O L
R W X U P Z L R K E T S R S T R A T O S P H E R E
S M O P I Q U H E L E O E R C M Z Q U B D X L K C
S I T Z L B F E G E X K H O P K D H V O I F G U C
S B E C C M O A M Q N M P L E R B R F T L G M W I
T X U K E A P T H T P H S C W X O O L S D M E C A
O H P O L U L T R A V I O L E T M T P R S O L D T
P B E G P W H R M R N U P U O A Z C C O B L O F L
S R V R P B I A C V S G O X S R V E P E M W K V O
N F L N M S H N V C R A R E C E S D X N L A M N V
U V R C Z O A S D M K D T M A B G N U D J L O C O
S T J L S G M F H M A O F T L N K O T L F I O K T
A R G Y O M Q E E N I I J S D U O L C U T E E E O
M O S H M O E R T U D L U P Q R S G S A E P D M H
B A I F H Q G K L E M F L Y W H E E L H R I N Q P
R P S M X B N O U P R V M Z K C P O R Y G P E K P
L V E H J S A I T S S P I Q R T S L F R P R T G A
Z F H O V A H M X Y O A O S S N M O L S E E O M O
O A T W T R C S P O L L U T I O N L E H Y P O E R
D R N M A M X D L P A J A I U B F U P V G P B P E
K S Y Z S E E V E R R S E R J W L S X U J O T G F
O U S P E C T R U M E N F K I U O E G M G C A W L
A G O H A X A M D I N Z L H K M Y N L S M T C O E
P L T E M P E V L F E U B C T L E T Z I H K K S C
G X O D K O H P U Y R W M A Q T J T R K G M B M T
F E H U F H T M T K G D H M E N K S E C Z H N T O
T D P R L U H K B W Y N O I T A I D A R A M T O R

SOLAR HEAT

R A E L C U N A T Y S U N I B U S T P O V A Y X
W O V N E O C G H T L K C C L Y T N D K L T A B
C V N W N D L J Y O I U A T A E H M P X I H C I
L D E I O X J R S X O L C I C P W E U C L E A T
Z T C E L L O C N H O O O T K I T L I O O R I S
E A R S T F K Y C R L P C D F Y A R C O Q M B Y
F G C L O Y Z P I C A L H T S R T H Y O L A R B
E G K A F S A M M Y Y T E R Q C C H Y X Q L L R
I C M E A L E I S A G P R U E S A M N U Y S T O
P E A R T T S O C K M R S L S T U M O T I Q S S
M A T N E S O U R C E P E I W H I T I R U A S B
I O R R A B D E K L M A N N K E I M S B B I D A
Z O P S E S K L U Y C M N S E P Q L U I C X Q Y
K A B K O V W E R E Q U C U L E M R F Q E E R S
O S X Y M D N L M N Q O E L S A N D C T E Y F A
T V X Y R A M O G E N E R A T E I R E W O P B S
S C O A L H T I C R Q C L T I N W U R T I M L B
E T L H U N E R E G F I T I I W A Q B S T R O U
S O R E L M T R P Y M U B O A S M W U I A E T B
S W C B N V T P O O W S V N K L G H T E U I S H

Solar
Insulation
Energy
Absorb
Black
Styrofoam
Collect

Calorimeter
Generate
Power
Gas
Electricity
Oil
Sun
Heat

Coal
Source
Fusion
Convert
Burn
Nuclear
Thermal

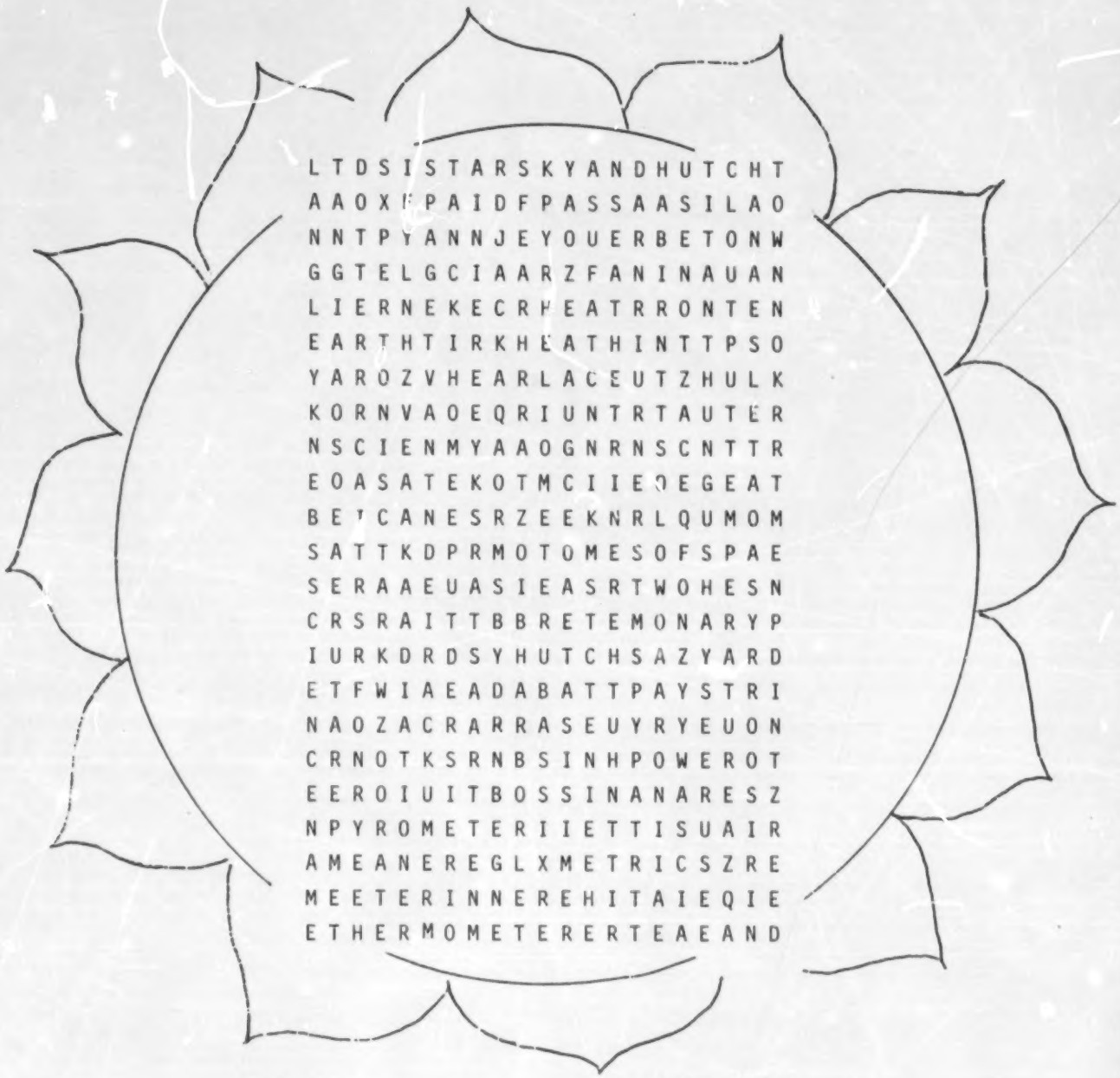
DISCOVERING THE SUN

Ultraviolet	Transfer	Spectrum	Pollution
Visible	Clouds	Reflector	Energy
Light	Sunspots	Solarimeter	Collector
Heat	Solar	Pipe	Radiation
Copper	Energy	Troposphere	Insolation

S P E C T R U M F C N T
P G T H G I L F E O S R
Y S U T M L T N I L O O
Z Z U E Z X R T S L L P
H F S N C T A B C E A O
H D S F S L V I G C R S
H L A M O P I D M T I P
E S D S O C O P L O M H
A N N T P L L T S R E E
T I E J U O E F S E T R
T P O L L U T I O N E E
R S U E X D Y F L E R P
A M Y L P S S S A R A I
N H V M A R R W R G D P
S R V I S I B L E Y I R
F P R N Q S T M N N A E
E O D O N N E L E E T P
R E F L E C T O R E I P
C O V I L L H A G U O O
F D R E L L A L Y Q N C

How many other words can you find?

SOLAR ENERGY WORD FIND


L T D S I S T A R S K Y A N D H U T C H T
A A O X I P A I D F P A S S A A S I L A O
N N T P Y A N N J E Y O U E R B E T O N W
G G T E L G C I A A R Z F A N I N A U A N
L I E R N E K E C R H E A T R R O N T E N
E A R T H T I R K H E A T H I N T T P S O
Y A R O Z V H E A R L A C E U T Z H U L K
K O R N V A O E Q R I U N T R T A U T E R
N S C I E N M Y A A O G N R N S C N T T R
E O A S A T E K O T M C I I E O E G E A T
B E T C A N E S R Z E E K N R L Q U M O M
S A T T K D P R M O T O M E S O F S P A E
S E R A A E U A S I E A S R T W O H E S N
C R S R A I T T B B R E T E M O N A R Y P
I U R K D R D S Y H U T C H S A Z Y A R D
E T F W I A E A D A B A T T P A Y S T R I
N A O Z A C R A R R A S E U Y R Y E U O N
C R N O T K S R N B S I N H P O W E R O T
E E R O I U I T B O S S I N A N A R E S Z
N P Y R O M E T E R I I E T T I S U A I R
A M E A N E R E G L X M E T R I C S Z R E
M E E T E R I N N E R E H I T A I E Q I E
E T H E R M O M E T E R E R T E A E A N D

LANGLEY
LATENT HEAT
OUTPUT TEMPERATURE
PHASE
POWER
PYRANOMETER
PYRHELIOMETER
PYROMETER
RADIATION
TEMPERATURE
THERMOMETER
WATT

SOLAR ENERGY QUIZ

Match Column A with the underlined scrambled words in Column B

	COLUMN A		COLUMN B
1	Pyranometer	_____	mpeeeurttra
2	Albedo	_____	tsrobainop
3	Langley	_____	deabol
4	Collector Box	_____	leroctocl oxb
5	Incident Angle	_____	emrhtoemetr
6	Temperature	_____	gyla?ne
7	Pyrheliometer	_____	idintcne nagel
8	Collector Efficiency	_____	fiencifeyc ellooctrc
9	Thermometer	_____	retnyrapome
10	Absorption	_____	prhetoilermey

JUMBLES

Unscramble the letters below into a word. The letters circled will give the answer to the statement below when unscrambled.

R O A L S

B I T G N U

P I C S L E E

M E C T R U P S

G E N R E Y

BATHERS' BOTHER

P U S T O S N

D U C O L

L M I N D I N L

G H T I L

L O C E R C T O L

ASTHMATICS' AGGRAVATION

A SOLAR PERSPECTIVE

Select the words that best fit the definition and read the vertical message.

When the moon comes between the earth and the sun

Shiny articles ___the sun's rays

The middle layer of the atmosphere

Radiators heat rooms by

Solar cells are also called ____cells

Light can be broken down and observed as a

Light we can see is called

TV interference is often caused by

Florists have used this solar collector for years

Green plants use the sun for

An instrument used to measure temperature

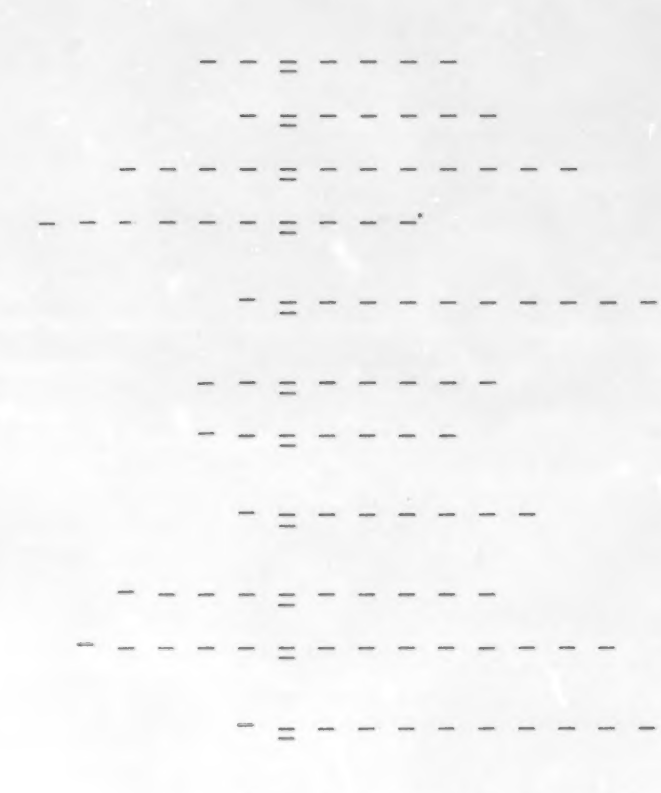
Found in Holland, they use a form of the sun's energy

The ability to do work

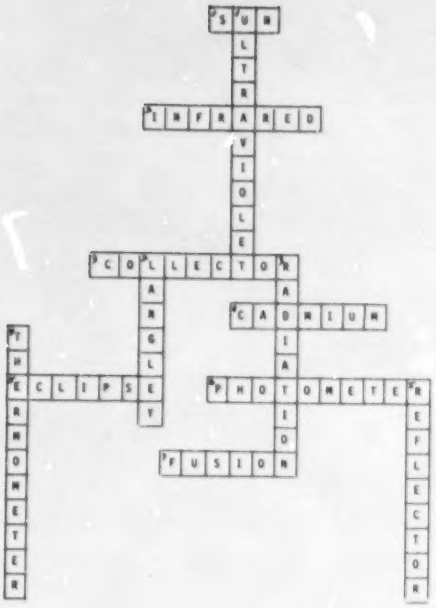
Used as piping in solar collectors

The sun's rays come to earth as

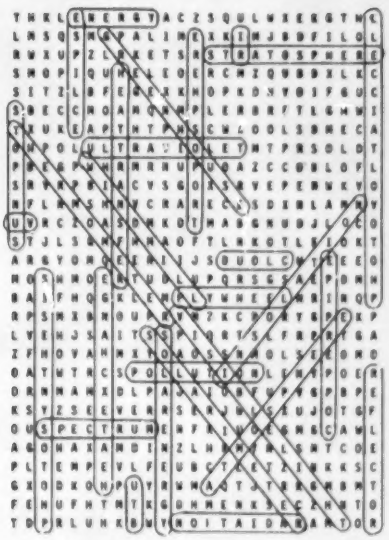
Light waves sometimes used in cooking



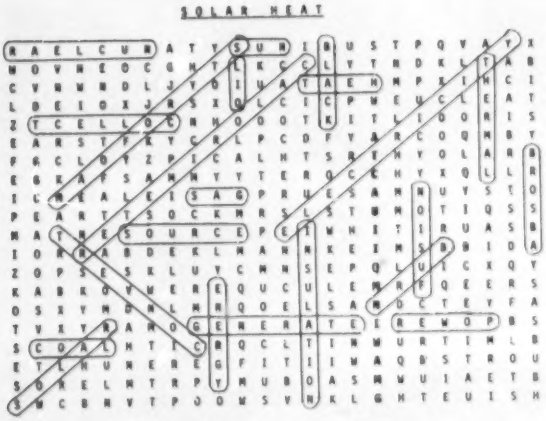
ANSWERS



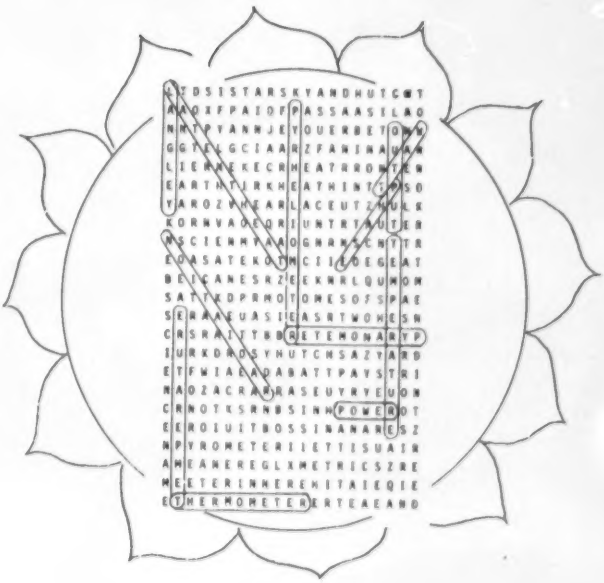
SOLAR ENERGY PUZZLE



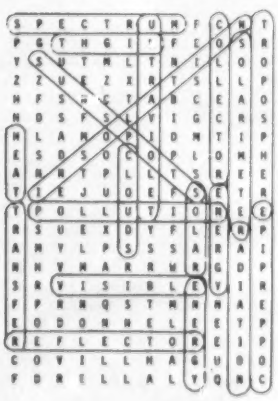
SOLAR HEAT



SOLAR ENERGY WORD FIND



DISCOVERING THE SUN



SOLAR ENERGY QUIZ

Match Column A with the underlined scrabbled words in Column B

	COLUMN A		COLUMN B
1	Pyranometer	6	mpeeeurttr
2	Albedo	10	tsrobainop
3	Langley	2	deahol
4	Collector Box	4	lerortacl oxb
5	Incident Angle	9	emrhtoemetr
6	Temperature	3	gylalne
7	Pyrheliometer	5	idintcne nage
8	Collector Efficiency	8	fiencifeyc ellooctre
9	Thermometer	1	retnyrapome
10	Absorption	7	prhetoilermey

JUMBLES

Unscramble the letters below into a word. The letters circled will give the answer to the statement below when unscrambled.

ROALS	S O L A (R)
BITGNU	I (U) (R) I (N) G
PICSLEE	E C L I P (S) E
MECTRUPS	S P E C I (R) (U) M
GENREY	E (N) E R G Y
BATHERS BOTHER	S U N B U R N
PUSTOSN	S (U) N S (P) O T
DUCOL	C L (O) U D
LMINDINL	M (I) (N) D M I L L
GHTIL	(L) I G H (T)
LOCERCTOL	C O L (L) E C T (O) R
ASTHMATICS AGGRAVATION	P O L L U T I O N

A SOLAR PERSPECTIVE

Select the words that best fit the definition and read the vertical message.

When the moon comes between the earth and the sun	ECLIPSE
Shiny articles ___the sun's rays	REFLECT
The middle layer of the atmosphere	STRATOSPHERE
Radiators heat rooms by	CONVECTION
Solar cells are also called ____cells	PHOTOVOLTAIC
Light can be broken down and observed as a	SPECTRUM
Light we can see is called	VISIBLE
TV interference is often caused by	SUNSPOTS
Florists have used this solar collector for years	GREENHOUSE
Green plants use the sun for	PHOTOSYNTHESIS
An instrument used to measure temperature	THERMOMETER
Found in Holland, they use a form of the sun's energy	WINDMILL
The ability to do work	ENERGY
Used as piping in solar collectors	COPPER
The sun's rays come to earth as	RADIATION
Light waves sometimes used in cooking	INFRARED

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